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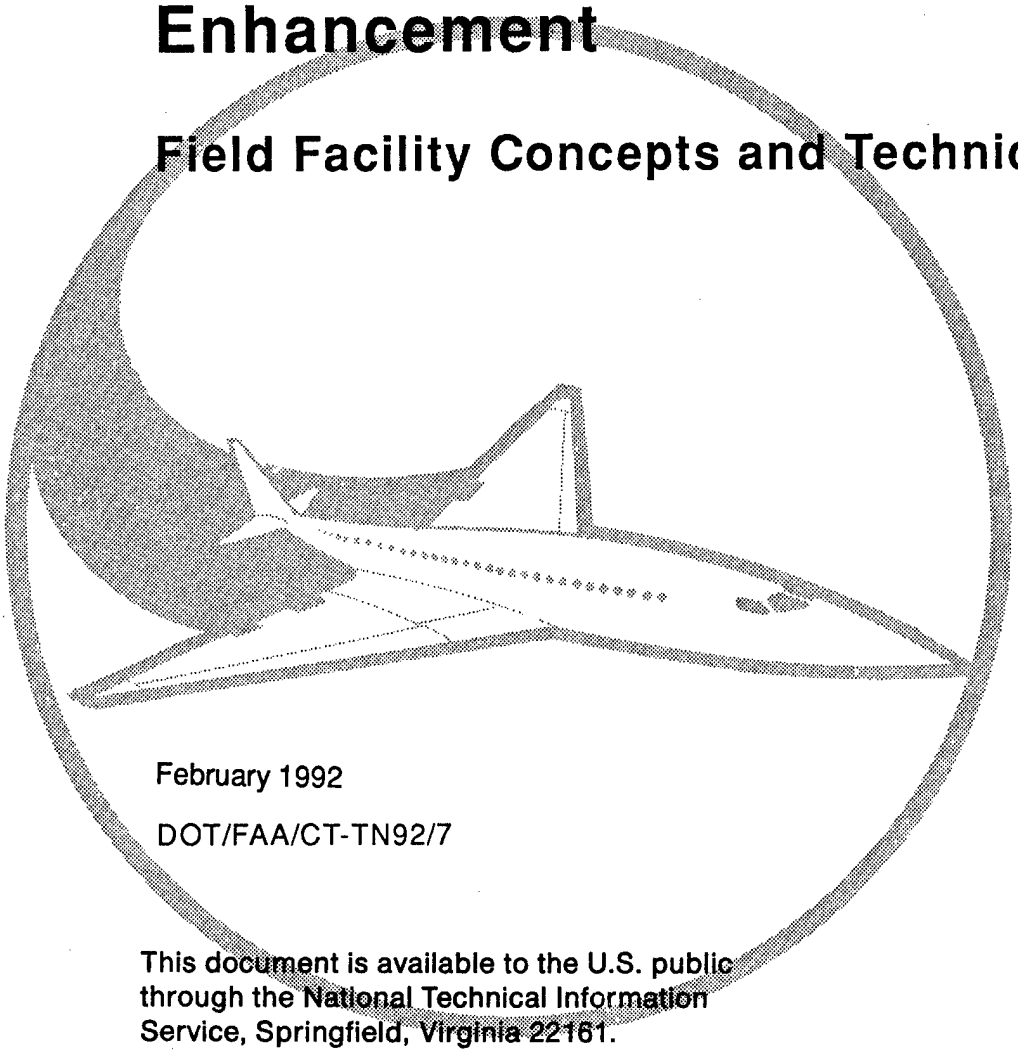
Controller Memory Enhancement

Field Facility Concepts and Techniques



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16. Abstract

This report presents the results of the second year's efforts in a 3-year project to study the role of memory in air traffic control activities. The goal of the research is to improve controller performance of tasks where memory is a critical element. The specific goals of this research were to identify memory aids currently in use and to explore the techniques that controllers use to manage memory. This work is part of a larger effort of the Federal Aviation Administration (FAA) to identify and to reduce the incidence of factors associated with operational errors.

Research staff conducted in-depth interviews with 170 controllers and a mail survey of 41 facilities managers in 1991 to obtain information on a range of topics including: the incidence of memory lapses, techniques controllers use to maintain awareness, perceptions of the characteristics of outstanding controllers, reported techniques and memory aids currently in use, and views on effective training techniques.

The report lists memory aids currently in use or known at FAA facilities. It includes recommendations for further research on techniques for managing memory, on the environments that promote use of memory aids, on particular memory aids, on successful training approaches, and on the establishment of a central clearing house for dissemination of information about these topics.

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We gratefully acknowledge the assistance of 170 controllers, 41 facility managers, and various supervisors, staff, and other personnel in conducting this research on the role of memory in air traffic controller activity. The controllers spoke at length about their training and work during in-depth interviews held at Federal Aviation Administration facilities throughout the country. The managers or their designated agent completed a mail questionnaire concerning memory aids and techniques associated with memory management. We appreciate their insights and their taking the time to share their experience in this research effort.

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EXECUTIVE SUMMARY

A total of 170 air traffic controllers throughout the U.S. described their experiences and techniques in managing air traffic during the course of 45-minute, in-depth interviews conducted in 1991. The goals of the research were to discover the techniques and actual memory aids that controllers use to help them reduce reliance on their memory in carrying out daily tasks. In a related study, 41 managers of Federal Aviation Administration (FAA) facilities reported on the memory aids in use at their facilities in response to a mail survey. A list of the aids identified in these studies appears in appendix A of this report.

Although there are over 40 memory aids currently known or in use at FAA facilities, a large proportion of controllers and their supervisors believe that real controllers do not need to rely on such aids. They regard most aids as something for "weak" or for "over the hill" controllers.

Currently, controllers say that the three memory aids that they use most involve strips:

1. Strip management: the arrangement of flight progress strips in a logical manner
2. Cocked or tilted strips: angling the strip in the strip bay -- an indication that further action is needed
3. Strip marking: keeping the strips updated as to commands issued and confirmed.

Almost all controllers use strips, at least some of the time. However, most controllers realize that their primary task is to scan radar scopes and traffic patterns; when they get busy, they stop or de-emphasize strip marking. Half of the controllers who say that they strip mark under light to normal traffic conditions, stop their strip marking when they get busy.

Controllers openly state that the nature of their work and their current operating procedures lead to frequent memory lapses. Most (9 out of 10) controllers relate having one or more memory lapses -- defined as an inability to instantly recall essential information pertinent to safe, orderly, and expeditious handling of traffic. A few report having memory lapses daily. Half of the controllers tell about having a lapse that resulted in a system error, that is, a situation in which two or more aircraft have less than mandated horizontal or vertical separation.

At the time of the memory lapse and system error, many controllers say that they did not feel any need for memory aids or joggers because traffic was light and/or their normal operational procedures did not include memory joggers. Most continue to rely on their memory alone, working without back-up procedures that would alleviate some of the demands on controller memory.

Nine out of 10 controllers contend that they experience boredom on the job. Most have some strategy to deal with boredom although few report use of memory aids. Instead, they tend to find work or talk to other controllers.

Controllers express how they knew when they were reaching their limitations with respect to memory when handling traffic. Most describe physical symptoms that they associate with high stress and a critical work situation. Few controllers explicitly associate their stress with the number of activities taking place. Their response to a "scrambling situation" is to "hang tough." The controller environment tends to discourage asking for help. In addition, many controllers may not be aware that they are entering a highly stressful situation and may only recognize afterward that they have approached or reached a limit.

When controllers describe the characteristics of an outstanding controller they say that he or she:

1. Preplans, prioritizes, and anticipates
2. Is knowledgeable
3. Has good communication skills
4. Uses an organizing principle in their work, such as standardization or initially "completing the transaction."

Most controllers do not refer to having a good memory as a feature of an outstanding controller; they also do not mention use of memory aids. However, they do admire use of techniques that allow controllers to manage memory requirement by routinizing or standardizing the way they handle the job.

Most controllers say that no one ever teaches them how to use their memory. They learn on their own, using techniques of repetition and association, in rote processes. They say that their most effective training occurs on the job and they have a range of suggestions to enhance the training experience and to make it more effective.

In summary, controllers do not explicitly learn how memory is involved in their work. They learn operating procedures that stress radar scanning with no particular emphasis on working techniques that would allow them to manage memory better, e.g., standardization techniques and/or use of memory aids. In addition, standardization techniques work best when all controllers adhere to a facility-wide approach to working. Currently, controllers are not trained to use aids except where their use is standardized and application is mandatory.

There are many job situations in which professionals work with a built-in back up system because experience has shown that the redundancy is essential. Pilots use check lists for a variety of activities, e.g., landing, take-off, or in-flight preparatory to landing. Stock traders, who work under extensive pressure, must have a written record of each transaction. In the medical profession, doctors and nurses write down all tests ordered, medicines, or procedures prescribed for patients. Computer systems are another instance; most facilities make back-up copies of files on a regular basis. In these examples, the back-up device is not only an accepted part of the system, it is mandated; it is not considered as a practice that taints the worker who uses it.

The results of these studies indicate that there are already a wide variety of memory aids and techniques that some controllers are using to manage their work and to decrease the demands on their memory. However, there is resistance to using these aids for several reasons. Controllers are not aware of their memory limitations with respect to traffic volume and complexity. They receive no training about memory, about ways to enhance it; or about the usefulness of memory aids. At the facility level, most controllers work in an environment that promotes autonomy of the individual controller. They do not learn standardized operating techniques incorporating back-up devices or memory aids.

The report includes recommendations for further research on techniques for managing memory, on the environments that promote use of memory aids, on particular memory aids, on successful training approaches, and on the establishment of a central clearing house for dissemination of information about these topics.

1. INTRODUCTION.

1.1 SCOPE.

In 1990 the Federal Aviation Administration (FAA) documented that 873 operational errors occurred in the air traffic control (ATC) system, (FAA, 1991). This number represented a decline from the previous year in which 913 were recorded. An operational error is an ATC term referring to a situation in which two or more aircraft have less than the required standard vertical or horizontal separation (FAA, 1989). Such errors have a wide range of consequences, from those that are barely technical violations to those that pose threat to life and limb (Paul, 1990). Fortunately, most do not fall in the most serious category and fewer still actually result in accidents.

Regardless of the severity, all operational errors are a serious concern. The ATC system is a complex command and control operation which is heavily dependent on human operators. These are men and women who take tremendous pride in their work as air traffic control specialists (ATCSs). They are a highly trained and professional work force. Despite their training and motivation they make mistakes which may develop into operation errors, i.e., failures to maintain the minimal required vertical or horizontal separation between aircraft. Kinney, et al., (1977) studied the causative factors of operational errors. They concluded that the underlying factors (which they considered to be direct causes of systems errors) were improper training or inadequate supervision.

1.2 PURPOSE.

There is consensus that the most common cause of accidents in aviation is some form of human error (Nagel, 1989). The purpose of this study is to identify effective methods and aids that air traffic controllers use to avoid one type of human error, memory lapses. By avoiding memory lapses, they can reduce the incidence of operational errors.

Communication of personal techniques and facility-specific tools for reducing memory lapses has been extremely limited in the past. There has been no means of gathering such information and distributing it throughout the FAA system. This study began with the belief that by identifying the skills and methods currently in use, and by publishing and distributing the results, all controllers could have access to tools that some of their peers have already successfully employed. The primary purpose of this research was, therefore, to collect, organize, collate, interpret, and distribute the memory aids, skills, and techniques already being used by successful controllers.

1.3 BACKGROUND.

Memory is one of a number of elusive constructs within the human performance equation. It cannot be observed directly and must be inferred from the behaviors of the individual operator.

Human operators are limited in terms of the volume and speed of information they can process (Finklman and Kirchner, 1980; Spettel and Liebert, 1986; Warm and Dember, 1986). It is generally recognized that memory is a limited resource. When people reach the limits of their capacity, they often try to minimize the demands placed on their memories by employing simple and familiar strategies. This can lead to a misinterpretation of available data and a subsequent misunderstanding of the current state of the system being operated (Murphy and Mitchell, 1986). Systems should be designed so that operators are not overloaded (Kantowitz and Sorkin, 1983).

The FAA has become increasingly concerned about actual and potential operational errors of air traffic controllers. The ATC system is highly complex and dynamic. As new hardware and software systems are developed, it is essential to understand how controller memory is influenced. Each controller is exposed to a virtual river of information which flows through his or her work stations at a pace an individual cannot completely control (Sperandio, 1971; Kirchner and Laurig, 1971; Thomas,1985). In order to manage the airspace within his or her domain, a certain amount of this information must be captured and retained primarily for tactical (3 to 5 minutes) use and secondarily for strategic planning.

Given current technology, the human operator must learn and retain critical information for a given task. Operators frequently use strategies for storing information. It is likely that the complexity and number of strategies employed have a major impact on job performance (Rasmussen, 1988). According to Vicente (1990), one can never fully understand the complexity of a job until the strategies that operators use in it have been identified. Strategies that do not allow for adequate storage, search, or retrieval of key elements of operational data can lead to detection or decision errors. To date, there is no clear documentation concerning the memory demands placed upon controllers in their daily activities. This deficit will become even more serious as new Advanced Automation Systems (AASs) come on line.

An FAA administrator's task force in 1987 studied the frequency and possible reasons for operational errors. The search for the causes of controller error has been on going for many years and the task force's conclusions centered primarily on two of the more well recognized categories: controller visual scanning and controller memory lapses.

While memory is the focus of this project, it is only one of the components of human operations that can lead to error. In another study, Kinney, et al. (1977) analyzed FAA reports of errors and developed eight categories of contributing factors:

a. Controlling in another's airspace

b. Timing and completeness of flight data handling

c. Interpositional coordination of data

d. Use of altitude on the display

e. Procedures for scanning and observing flight data

f. Phraseology and use of voice communications

g. Use of human memory to include relying on recall in a noisy environment

h. Dependence on automatic capabilities.

In examining the tasks involved in ATC, the contributing factors for errors, and the various theoretical approaches, it appears that memory may be a component of almost everything controllers do. An interagency near-mid-air-collision working group has suggested specifically that the FAA: "Develop and ascertain the feasibility of the FAA Technical Center's controller memory enhancement research for incorporation into training programs" (FAA, 1989, p. 5-2).

Most system designs do not clearly address the memory component of the operator's task structure. Further, they do not attempt to optimize the demands placed on the operator who may well be the center of the operation. This situation is not surprising since memory load is usually not addressed in design standards. Probably the most widely referenced document for user interface issues in systems design is MIL-STD-1472D Military Standard Human Engineering Design Criteria for Military Systems, Equipment and Facilities (Department of Defense, 1989). There is only one statement in this lengthy publication that focuses on memory: "The requirement to learn mnemonics, codes, special or long sequences, or special instructions shall be minimized" (p. 265). Ironically, ATC is all about mnemonics, codes, special sequences, and special instructions.

Controlling aircraft in today's crowded skies is a complex and dynamic process. Air traffic controllers are surrounded by sources of information from which they must select critical data. They code and store in their memories a portion of the data. However, they do not always do this effectively. One of the most common expressions uttered by controllers who have made an operational error is: "I forgot!" In the spring of 1987, an FAA operational error task group identified memory enhancement as an important area which could potentially decrease the frequency of errors (Operational Error Analysis Work Group, 1987). The Federal Air Surgeon approved a program directive with the Technical Center in May 1988. This led to an effort to make maximum use of what is currently known about human memory. After identifying a set of basic principles, a Controller Memory Handbook was developed (Stein and Bailey, 1989).

The authors of the Handbook, one of whom is currently a controller, took the scientific literature on memory and addressed the specific needs of air traffic controllers, using graphics and text. The distribution of the Handbook provided an excellent opportunity to ask about the techniques controllers were currently using and to assess the impact they felt that memory had on their everyday operations. A questionnaire was distributed with each batch of handbooks that was sent out to field facilities. This preliminary field research produced data relatively fast and inexpensively; however, it lacked the sophistication and flexibility of field interviews that are the basis of this current report.

In all, 299 out of 550 questionnaires were returned during this initial phase of research; the results appear in a technical note: Air Traffic Controller Memory--A Field Survey (Stein, 1991). Respondent controllers emphasized the importance of memory in their everyday

operations. They identified a number of key factors which influenced their memories, including coordination, attention, distraction, fatigue, change, position, relief briefings, and overload. When discussing techniques that they used to try to reduce memory lapses, the respondents focused on standard procedures that they refer to as "good housekeeping." This involves controllers being extremely methodical and systematic about their tasks.

One indication of how seriously the FAA has taken the issue of memory lapses was demonstrated when the concept of memory was introduced into the training of new air traffic controllers. After the Memory Handbook was printed, the staff at the Mike Monroney Aeronautical Center in Oklahoma City developed a training module that focused on both operational listening and memory. The memory portion was based on the theory and practical ideas expressed in the Handbook (FAA, 1990). The module employed a programmed text format and some of the Handbook graphics.

In a related effort focusing on the theoretical grounding of memory and ATC, Princeton Economic Research, Inc. (PERI), under contract to the FAA, conducted a literature search and developed an initial theoretical model of memory requirements of ATCSs. They also developed specific proposals for job aids in the ATC facilities; see appendix A for a list of these aids. (Vingelis, Schaeffer, Stringer, Gromelski, and Ahmed, 1990. This is also referred to as the PERI Report.) These authors offered an operating definition of the construct of working memory. Rather than offering a simplistic definition, they chose to define the construct in terms of its:

a. Functional requirements such as attention and rehearsal

b. Contents, including aircraft data, position, capacity (seven plus or minus two elements)

c. Limitations, such as interference, within a 3 to 5 minute tactical window.

This approach assumes that attention is necessary for information to enter working memory and that some form of rehearsal is essential to keep it there long enough to be useful. Their concept of capacity is based on Miller's (1956) proposal that working memory for human information processing has a capacity limited to approximately seven "chunks" or units of related data. In the ATC environment, this means that most controllers could handle approximately seven items of information at a time. The so-called magic number seven (plus or minus two, or from five to nine) has had amazing resiliency over the years. Although it is an over-simplification, it is still a useful starting point. Subsequent research data and practical experience have indicated how situational elements and experience can affect memory capacity (Chase and Simon, 1973; Ellis and Hunt, 1989).

In the PERI Report (1990) the authors view memory, and working memory in particular, as organized hierarchically. The most important information, such as possible aircraft conflicts, is at the top and most accessible for retrieval while less relevant data are closer to the bottom of the hierarchy and, therefore, less available for retrieval. They note that the long term memory of a controller contains past experiences, procedures, and preferences which will

influence specific retrieval strategies; thus, long term memory has an impact on the operation of working memory.

PERI's unique approach involved the application of a theory of cognitive behavior to the conceptualization of appropriate memory aids. The theory was developed initially by Rasmussen and Lind (1982) and later amplified by Rasmussen (1987). It is centered on three levels of individual skill acquisition. The lowest level of skill acquisition concerns skill-based knowledge; this knowledge often involves highly over-learned sensorimotor routines such as riding a bicycle or operating some sort of manual control. Tasks that call for skill-based knowledge do not place a heavy mental load on the operator. The skill-based level has its own type of errors and the type of memory aids that help by providing appropriate cuing of the correct behavioral routine.

The next level of performance is rule-based. Here the individual must choose the appropriate rules and procedures that he or she has learned through experience. The process of choosing requires a higher level of information management that will call for both working and long term memory. Memory aids that would be effective at the rule-based level include cuing, aids to association, analogs, and examples.

The highest level of skilled performance is knowledge-based. This is developed through experience and goes well beyond the sequential application of rules. The operator can make logical leaps and reach a solution to a problem quickly. However, people operating at this level still make errors, some of which can be traced to memory lapses. The mental models that they have created may be inappropriate for the immediate situation or they may have applied their knowledge before they had a complete set of necessary information. For this type of situation, the PERI team suggests that the aids for memory must be highly sophisticated. The aids should involve management information systems and automated decision aids so that the support system can operate as fast as the human decision maker can. They suggest that . . . "a potential benefit of increased automation is more efficient gathering, collating and presenting of information" (p. 39).

The authors went on to suggest a number of possible memory aids for the current relatively non-automated ATC system. This research was based primarily on library sources and the experience of one of the authors, a former air traffic controller. To build on that foundation, the data for this current report were gathered at field facilities in order to draw on the experiences of many controllers located throughout the country.

2. METHOD.

2.1 MANAGERS' SURVEY.

In the course of evaluating early versions of the Controller Memory Handbook, it was evident that field personnel had a great range of ideas about memory management and its relation to ATC work. Before moving on to field interviews (an expensive and time consuming effort) a preliminary instrument was developed for use in canvasing facility management at towers of level 3 and above and at en route centers. The purpose of this initial effort was to determine

the potential for in-depth interviewing procedures and to evaluate the level of interest for more intensive data gathering among facility management. A mail survey of management was adopted for several reasons:

a. These senior, experienced personnel have grappled not only with their own memory limitations but also with those of their subordinates, whom they had trained, supervised, and often evaluated.

b. These respondents are more likely to have a facility-wide perspective and could take a more global view of operations.

c. In surveying only management at this phase, there were no labor-management issues to be resolved to obtain the data.

2.1.1 Survey Development.

The survey instrument was written and revised based on past research and current ATCSs input. This input was supplied by local FAA controllers at the Technical Center and by a member of the research team, a retired tower controller. A complete copy of the survey is included in the appendix of this report. The survey consisted of a few demographic questions (geographical region, facility level, number of controllers) and 11 open-ended questions plus 1 item requiring a yes or no response. The questions focused on the availability and use of memory aids and on-the-job strategies. There were also questions on equipment currently in use as well as automation tools that managers know about but have not installed.

2.1.2 Sampling Strategy.

A total of 83 surveys were sent out and 41 were returned, an overall response rate of 49 percent. Table 2-1 shows the response rate by type of facility.

All en route centers and a subset of the towers at level 3 and above received a copy of the survey. Towers were purposely selected, based on size, activity, complexity, and regional location; no assumption of random sampling was made. The survey was addressed to facility managers and contained a cover letter which asked the manager or his or her representative to complete it and return it in the self-addressed envelope.

2.1.3 Description of Participants.

In most cases, it appears that a senior operations or training specialist designated by the facility manager completed the survey.

TABLE 2-1. RESPONSE RATE BY TYPE OF FACILITY

Type of Facility	Total Sent	Return	Percent Returned
Total	83	41	49%
Center	21	13	62%
Terminal/Tower	62	28	34%

2.2 ATCS FIELD SURVEY.

The results of the Managers' Survey confirmed that personnel in the field facilities not only had knowledge about memory management but interest in the topic as well. It was decided to follow up the previous data collection activities with a series of field interviews. This phase of the research is referred to as the ATCS Field Survey.

Mail surveys, such as the Managers' Survey, are convenient and inexpensive to administer. Their major disadvantage is that researchers rarely receive any information except direct responses to the questions asked. There is no flexibility and no allowance for branching or probing along profitable lines of inquiry. A personal interview heightens the importance of the topic and the research to the respondent. The interviewer may also affect the respondents in some way, e.g., encouraging some lines of discussion. However, the major advantages of the in-depth interview are that the interviewer can:

a. Ask for examples to clarify a point

b. Explore the meanings of various phrases that respondents use

c. Probe, that is, ask a question in a variety of ways, to ensure that he or she understands the point that the respondent is making

d. Observe body language of the respondent

e. Pursue new topics that the respondent may raise, thereby adding to the comprehensiveness of the data gathered.

2.2.1 Survey Development.

The interview protocol (or interview guide) for the ATCS Survey was a semistructured format, allowing the interviewer considerable latitude to explore the ideas and experiences of the controllers. Complete copies of the two protocols used are included in appendix B. A cover letter and copies of the protocol were sent in advance to the facilities with a request to forward

one copy to the local union for review. The letter (included in appendix B) alerted staff at the facility about the research in progress and its purpose; it mentioned that the researcher would call before arrival to discuss the plans. The letter also asked for assistance in identifying employees who may have knowledge and ideas concerning memory issues and could be available for an interview. Space was left on the interview protocol for the interviewer to record notes. The beginning of the form contained the standard reminder that the interviewer gave to each respondent to inform each person of his or her rights under the doctrine of privacy and informed consent. Names and personal identifying information were not collected.

There were a limited number of demographic questions such as participant's current position, years in ATC, years in the facility, etc. Then the interviewer took the participant back through his or her career, reviewing what they had learned, developed, or used in terms of memory aids over the years. There was also an effort to determine the degree to which the individual was aware of his or her limitations in retention and recall. The interview included 14 questions and generally took about 45 minutes to complete. The interviewer was free to expand on any of the answers given with follow-up questions not actually listed in the protocol. The process was not designed as a classic experimental model of research design. Instead, it was an in-depth exploration of the air traffic controllers' world; it produced detailed data about the training of air traffic controllers, how they manage their everyday activities, the nature of controller memory failures, and various memory aids and devices that controllers are already using.

One interviewer conducted all 170 field interviews. He is a retired FAA controller who was an area supervisor at a level 5 Terminal Radar Approach Control (TRACON) prior to retirement. He was specifically trained in interview techniques by the FAA Technical Center Psychologist, a member of the research team. An experienced in-depth interviewer also sat in on some initial interviews and provided feedback to the interviewer concerning pacing, probing, and other interviewing techniques. The use of one interviewer, while time-consuming, provided consistency across facilities and individuals interviewed.

The interviewer took notes during the interviews and, with the consent of the respondents, collected audio tapes from the majority of the participants. Some of the tapes were transcribed, prior to the analysis. However, due to the volume of the interviews collected, the tapes were viewed as primarily a back-up source of information and used to clarify details of the research notes of the interviewer.

After the first set of 56 interviews, the research team amended the original questionnaire, deleting questions that had limited responses and adding questions that were more relevant to the inquiry. For instance, the original protocol had one question about training with respect to the use of memory. Experience in the initial interviews indicated that this approach was too broad since controllers answered this question differently depending on what phase of their training they had in mind. The revised question asked about four different types of training at various sites: at the FAA Academy, in facility classrooms, in facility radar simulation, and on-the-job training to become position qualified.

The original goals of collecting, organizing, and interpreting skills, techniques, and memory aids were expanded to include other related topics, including:

Inquiry into the circumstances under which controllers learn their limitations with respect to memory, including whether they had ever experienced a memory lapse.

The conditions under which controllers use, stop using, or never use various memory aids.

How controllers handled boredom.

The techniques or skills that controllers use to manage their memories and their work.

The degree to which controllers rely on automated information.

The type of training controllers find most effective in learning their job.

The job habits and characteristics of those controllers that other controllers recognize as outstanding and effective.

Other information coming out of these interviews indicated that there is a rich store of information and expertise in various sites throughout the country, particularly on approaches or materials for training controllers that could be profitably shared with other facilities.

2.2.2 Sampling Strategy.

Interviewing controllers at sites throughout the country involves considerable travel and complicated scheduling. To maximize cooperation, sites that had responded to the Managers' Survey were given first priority, followed by facilities that were in the immediate geographic area. This strategy led to the organization of field trips ranging from 1 to 3 weeks. In all, 170 interviews took place at 25 facilities in 4 regions, as indicated in table 2-2.

TABLE 2-2. NUMBER OF FACILITIES VISITED BY TYPE AND REGION

Region	Centers	Towers/ TRACON	Total
Total	6	19	25
Eastern	-	2	2
Great Lakes	2	5	7
Northwest Mountain	2	4	6
Western-Pacific	2	8	10

The initial 56 interviews were conducted in the Eastern and Great Lakes regions. The remaining 114 were done in the Northwest Pacific and Western-Pacific Regions.

2.2.3 Description of Participants.

The participants represent a wide range of air traffic controllers, from those with half a year of experience to those with 34 years of experience. Due to the objectives of the study, however, there is a preponderance of more experienced controllers. Table 2-3 describes the general characteristics of the respondents.

TABLE 2-3. CHARACTERISTICS OF THE INTERVIEWED CONTROLLERS

Characteristics	Number of Controllers	Average
Total	170	
Level		
Full Performance	103	
Staff/Supervisory	46	
Development	21	
Years as ATCS		
Less than 7	36	
Average Years		3.8
7 or more Years	134	
Average Years		13.4
Average Years in ATCS, Total		11.4
Years at Current Facility		
Less than 1 Year	16	
1 - 9 Years	128	
10 or More Years	26	
Experience at Other Facilities		
More than 1 Facility	104	
At 1 Facility Only	66	
Controller Status		
Hired After Controller Strike in 1981	109	
Hired Before 1981 Strike	61	
Longest Active ATCS Career		34.0
Shortest Active ATCS Career		.5

3. RESULTS.

3.1 PERCEPTIONS ABOUT THE OUTSTANDING CONTROLLER.

Initially, the controllers were asked to describe any special attributes or techniques that "controllers who handle large volumes of traffic with ease have..." In the later interviews, the question was changed slightly, to ask: "Think about the controllers that you would rate as outstanding. What special skills, attributes or techniques do they have?"

The descriptions that controllers give in answer to either question (the outstanding controller or the controller who handles large volumes of traffic) are fairly consistent. The controllers in the in-depth interviews usually mention more than one characteristic or attribute. The top category, mentioned by slightly over half of those interviewed, focuses on preplanning, anticipation, or awareness. The most frequently mentioned characteristics, by rank order of mention, are in table 3-1.

No matter which way the question is asked, controllers give similar answers. The only major difference between the two ways of asking the question is that when controllers talk about the person who can "handle large volumes of traffic easily," they are more likely to mention experience as a characteristic of such a controller. In reviewing the ranked list, the first two categories overlap to some degree in that the first set of characteristics (preplanning, prioritizing, anticipating, and being aware) may be what other controllers see as being knowledgeable, knowing the basics, and being "professional" -- the second ranked set of attributes. However, about one in four controllers mention both categories, an indication that for many the two sets of characteristics are describing different aspects of the competent controller.

The third ranked category concerns good communication. Two out of five controllers mention "good phraseology" as a specific professional skill. While most mention the controller's speaking skills, a few mention attributes such as being a good or active listener, asking questions when appropriate, and having a structured approach, e.g., giving information first and instructions last.

In the fourth ranked category the controllers indicate techniques that organize ATCS work such as standardizing, visualizing, or initially "completing the transaction." Again, these may be examples of the behavior of controllers who are preplanning, aware, professional, and knowledgeable. About two in five of the controllers interviewed specifically mention such an organizing technique or principle.

About one in five controllers mention flexibility -- the ability to "go to Plan B," to improvise, or to adapt to an unusual situation; one in five also cite one of the following traits as a characteristic of an outstanding controller: self confidence, discipline, calm, "being a team player." A few controllers note that team work includes working well with pilots as well as with co-workers.

TABLE 3-1. CHARACTERISTICS OF THE OUTSTANDING CONTROLLER

Rank	Characteristics	Number of Responses*
1	Preplans, anticipates, prioritizes, is aware so he/she can act, not react	90
2	Is knowledgeable, knows the basics, has good techniques, is professional	78
3	Has good communication skills, uses "good phraseology"	74
4	Has some organizing principle, e.g., standardizes, initially "completes the transaction," "keeps it simple," and/or visualizes	70
5	Likes the job	40
6	Is a team player	38
7	Is self-confident, has self esteem	34
8	Is disciplined	33
9	Maintains a calm manner	32
10	Is flexible, able to do 3 or 4 tasks	31
11	Has a good memory	14
12	Is experienced	11
13	Has safety and/or service concerns	6

* Controllers usually mentioned several categories characterizing an effective or outstanding controller; therefore, the totals add to more than the total number of controllers.

Q.10. Initial Interviews: "To your knowledge, do controllers who handle large volumes of traffic with ease have an special attributes or techniques?"

Q.11. Revised Version: "Think about the controllers that you would rate as outstanding. What special skills, attributes or techniques do they have?

Less than 1 in 10 controllers mention having a good memory as a characteristic of an outstanding controller. Since the interview focused on memory, this area may have become salient as a result of the interviewing process. Having a good memory may be implicit in the more frequently cited characteristics of knowing the basics, being professional, and communicating well.

Few controllers specifically mention a concern for safety. Again, this characteristic may be implicit in other characteristics such as preplanning, knowing the basics, and good communication. Other general attributes that some of those interviewed associate with an outstanding controller are enjoying the job and having experience with the work.

In summary, ATCSs demonstrate some agreement about the characteristics and attributes that describe outstanding or highly competent controllers. The four top features they cite are:

a. An all around awareness and ability to preplan.

b. A high degree of technical expertise and knowledge necessary for the job.

c. Good communication skills.

d. Use of an organizing principle in his or her work.

The first three features require the ATCS to use his or her memory. The fourth item mentioned, use of an organizing principle such as standardization or initially "completing transaction," has the effect of helping the controller manage his or her memory.

3.2 REPORTED LIMITS ON PERFORMANCE.

3.2.1 Memory Lapses and Incidents.

A memory lapse is defined as the inability of an individual actively engaged in providing ATC services to instantly recall essential information pertinent to the safe, orderly, and expeditious handling of traffic under his or her control. Controllers call it "losing the picture." Typical lapses may involve:

Forgetting a piece of data such as:

aircraft call signs
currently/newly assigned altitudes
current or proposed change to route of flight
previous/newly assigned frequencies
previous/newly issued control instructions
computer keyboard entries
unusual or infrequently used procedures
who to coordinate with
what intercom line to use
the relative positions of aircraft under their control,

or a complete black out, or total loss of system awareness for more than a few seconds.

When controllers were asked whether they had ever had a memory lapse on the job, most ask for a definition of memory lapse. After hearing the definition above, most respond "yes;" for many, such lapses occur on a daily basis. Many controllers say that people who do not admit to having lapses are probably lying to themselves or trying to impress the interviewer.

When the interviewer asked whether a lapse resulted in a system error or deviation, over half (57 out of 104) of the controllers say that they experienced a system deviation or error, i.e., they experienced a situation in which aircraft had less than the required standard vertical or horizontal separation. (See table 3-2.)

TABLE 3-2. INCIDENCE AND NATURE OF MEMORY LAPSES

Responses	Total	Percent Yes
Had a memory lapse	111*	94%
Had a memory lapse that resulted in system error	104	55%

*Not asked in Initial Interviews, therefore total base of controllers is less than 170.
Q.6. Revised Version: "Have you ever had a memory lapse and, if so, how did it occur?" Follow up: "Did this memory lapse result in a system error/deviation?"

Controllers report a wide range of "I forgot" scenarios; they vary in severity from the inability to remember an adjacent sector frequency to completely forgetting (for an extended period of time) about an aircraft that the controller had under his or her control. The interviewer asked controllers if they were using memory joggers at the time of the memory lapse, e.g., cocking a strip or using a red marking to indicate that further action was necessary or any other memory aids to remind them that they would have further action to take with those aircraft under their control. Most say that they felt that there was no need for joggers due to the limited volume of traffic and their reliance on memory to recall actions that had to be taken.

Other controllers say that they never had an error or deviation but feel they are extremely lucky to have had another controller close by to catch their oversight and to have offered assistance. Most controllers feel that they were fortunate that these lapses occurred during periods of light traffic when they had sufficient time to take corrective action and conflicting traffic was not a factor. Controllers say that lack of traffic was the main reason that these memory lapses did not result in more system errors or deviations; the great preponderance of lapses reported were in forgetting to make a hand-off to the adjacent sector or center, thereby allowing traffic to penetrate someone else's airspace in an uncoordinated status.

The interviewer asked: "What techniques do you now employ to reduce the probability of this error occurring again?" Most responses allude to paying more attention to the situation at hand, especially when traffic volume is light, and to handling any potential conflict immediately. Some controllers say that they pay more attention to information on the strips and listen more intently to read-backs to prevent misunderstandings. Other controllers report using some form of memory jogger such as having an aircraft report leaving an interim altitude or passing a Distance Measuring Equipment (DME) fix to minimize the probability of forgetting about a particular aircraft. Also, controllers involved in a system error or deviation generally express a need for better scanning techniques; some recognize the need for the development of a back-up system to reduce reliance on memory.

In general though, controllers have negative comments about the use of memory aids. Some newer controllers believe that "real controllers do not rely on crutches (memory aids)." Others maintain that only controllers who are "over the hill" use memory aids.

3.2.2 Maintaining Awareness.

Controllers describe the situation associated with a system error. There are patterns related to these situations of memory lapse; they tend to occur when:

Traffic conditions are light to extremely light,

Controllers are engaged in non-work associated conversations,

Positions are combined, necessitating scanning a much larger than normal radar area or traffic pattern,

Controller training is in progress,

Other distractions are present, drawing attention away from the primary task of separating aircraft, or

The noise level in the control room was at a level affecting their ability to concentrate on control tasks.

Controllers who report that their memory lapse resulted in a system error or deviation, for the most part, claim that they allowed themselves to get distracted and then they lost situation awareness. Controllers are candid in explaining what happened. For example, "It was a stupid mistake that should never have happened," is a typical response. Most controllers are concerned about daydreaming during periods of idleness when inattentiveness to control duties and non-challenging situations lead to boredom; they feel that their vision and hearing functions get diverted to non-control concerns.

As a follow up to the questions about memory lapses, the interviewer asked explicitly about the extent to which they encounter boredom while working. Most controllers questioned (9 out of

10) say that they do experience boredom. Table 3-3 summarizes how controllers cope with boredom.

TABLE 3-3. STRATEGIES TO DEAL WITH BOREDOM

Strategy	Number of Responses
Try to find additional work	35
Talk to peers or supervisors	23
Force oneself to scan the scope or intensify concentration, or discipline oneself to pay attention	16
No strategy reported	8
Read the manuals, binders; review procedures	6
Clean up the work area (housekeeping)	5
Use comic relief or humor; joke	5
Day-dream, think of non-work topics	5
Stand up, walk around, change position	3
Use a note pad as memory jogger/aid	3
Slow pace to match traffic	2
Stick to the basic rules, don't improvise	1
Follow-up question in revised version, not asked of all controllers: "How do you cope with boredom?"	

The top two responses involve a majority of controllers who were asked this question; they report trying to find additional work or someone to talk to in order to relieve the symptoms of boredom. They also report using increased self discipline to scan the scope more diligently or to pay more attention to the task at hand. Relatively low on the list of "how do you cope" strategies are the reading, reviewing, and studying options. A few controllers report using a note pad as a memory jogger or aid.

TABLE 3-4. SELF REPORTED SIGNS OF STRESS RELATED TO MEMORY LIMITATIONS

Indications of Reaching Memory Limitations	Number of Responses*
When there is too much work to do and not enough time to do it	32
Fidgeting in a nervous manner	31
Sitting closer to the radar scope	28
Talking faster	28
Feeling adrenaline rising, faster heart beat	24
Feeling overwhelmed and out of control	19
Palms get sweaty	15
Frequency gets congested; repeat myself, "say again" too often	13
Starting to move around a lot or stand up in position	13
Sweating excessively	12
Feeling a need to increase my speed	11
Feeling uncomfortable at the position	11
Voice starts to break up; lose proper inflection	11
Sitting up erect in chair	11
Feeling nervous and anxious	10
Getting tunnel vision	10
Forcing myself to be more alert	9
Starting to forget; memory gets overloaded	7
Unable to preplan actions	7
Seat gets hot; I feel flustered	7
Getting unsure of decisions	6
Talking louder or softer	6
Feeling very tense	5
Lose my composure or temper	5
Double checking all work, clearances	5

TABLE 3-4. SELF REPORTED SIGNS OF STRESS RELATED TO MEMORY LIMITATIONS (CON'T)

Indications of Reaching Memory Limitations	Number of Responses
Feeling muscles tightening up	5
Feeling mentally exhausted	5
Getting strip fever (fear associated with a high number of in-flight progress strips)	4
Not wanting any more aircraft	4
Becoming totally confused	4
Having trouble breathing	3
Breathing deeply and rapidly	3
Talking slower	2
Pushing away from the scope	2
Noting that the "D" controller is way behind	1
Fearing the traffic	1
Feeling stressed out	1
Asking for help	1
Looking at the clock	1
Feeling a need to go to the bathroom	1
Having more than 4 things to do simultaneously	1

* Controllers usually mention several indicators of stress; therefore, the totals add to more than the total number of controllers.

Not asked in Initial Interviews.
Q7. Revised Version: "What do you see as your memory limitations as far as traffic volume is concerned?"

3.2.3 High Stress Situations and Stress Indicators.

One of the goals of the research was to determine if air traffic controllers knew when they were reaching their own personal level of traffic saturation. The interviewer asked how they knew when they were reaching their memory limitations as far as traffic volume and complexity were concerned. Most of the answers dealt with the controller's inability to accomplish specific tasks in a timely manner or a sense of discomfort. Table 3-4 gives the controllers' responses.

The situations listed in table 3-4 relate to what controllers refer as "scrambling situations." Of all the controllers interviewed, only one expressed the situation in terms of the number of activities going on at the same time; he could pinpoint exactly when he was approaching saturation and reaching his mental limitations. This controller felt that when he had more than four different things to do, he needed help to keep up with the traffic flow; at this point, he would ask a supervisor for help. Several controllers say that they get uncomfortable when they cannot preplan their actions; this is also a general awareness of reaching a limit. However, unlike the previous individual, these controllers do not appear to have a strategy for dealing with this type of situation.

Controllers report a great many "gut feelings" that are indicators of stress. There were a variety of nervous mannerisms or physiological cues that controllers report as associated with a traffic saturation situation. These reactions, detailed in table 3-4, range from fidgeting in a nervous manner to extreme distress.

Controllers tend to adopt a "hang tough" attitude in the face of overload. They report that they wait for a position to be decombined or for another controller to "get the picture" and offer assistance. Most do not ask for help. When they do ask for assistance, it may be too late to provide help by decombining a position or adding a controller.

TABLE 3-5. REPORTED TECHNIQUES AND MEMORY AIDS CURRENTLY IN USE

Personal Techniques	Number of Responses
Constant scanning, intense concentration, "complete the transaction"	36
Good phraseology, knowledge of basics, consistency, standardization, pre-planning	22
Visualization	8
Memory Aids (Backup Techniques)	
Strip management	97
Cocked strips, indicating action needed	84
Strip marking (own system or FAA required)	83
"J" Ring/ball (center)	45
Off-set leader lines, as direction indicators	38
Slant/O (center)	32
"RED" markings to indicate warning or for preplanning	29
Strip bay management	29
Note pad management (towers)	28
Vector lines (center)	26
Status boards/note pads/grease pencil marks	17

Implied function entries, ARTS scratch pad data (towers)	16
Timeshare software for information	15
Histories (center)	15
Interim altitude or other "flagging" scratch pad data (center)	15
Off-set data blocks as directional indicators	13
CRD display (center)	11
Highlight key elements to indicate action necessary	10
Color coded warning strips/plexiglass to indicate closed runway/ crossing (tower)	10
BRITE radar (towers)	9
Limited data block for advance information	7
Route lines (center)	6
Range bearing indicator (center)	5
Automatic arrival drop list (towers)	5
Extended leader lines	5
Black strip or strip turned over as caution reminder	5
Range marks for sequencing (centers)	4
Runway incursion device (RID) (towers)	3
Position report prior to reaching clearance limit	3
Double intensity of target	2

Q.3. Initial Interviews: What personal techniques do you use that help you maintain the picture?"
Q.3. Revised Version: "We are interested in memory as your use it. What personal techniques do you use that help you maintain the picture?"

3.3 REPORTED TECHNIQUES AND AIDS FOR MEMORY ENHANCEMENT.

The interviewer asked the controllers to describe how they use memory: "We are interested in memory as you use it. What personal techniques do you use that help you maintain the picture"? As a follow up, the interviewer went on to explain that he was interested in a wide range of aids, from using strip holders as sector dividers to using computer software.

The data in table 3-5 indicate two types of responses -- personal techniques and the memory aids that controllers report using. Note, however, that not every site has each type of FAA equipment. Also, job tasks for center controllers vary greatly from those in terminals, necessitating the use of site-specific aids or multiple aids.

a. Personal Techniques. Constant scanning, intense concentration, and operating to "initially complete the transaction" are memory-related techniques that one in five controllers (21 percent) report using. These controllers are placing priority on good techniques and basic work habits as compared to using memory aids to maintain situation awareness. Another 13 percent mention other types of good work habits, including using standard routes and phrases or preplanning, as their way of managing memory on the job. Standardization refers to routinizing and homogenizing activities so that there is a predetermined procedure for handling most tasks. (See sections 3.3.5 and 4.2 for more discussion of standardization.)

Another 5 percent of the controllers specifically mention visualization as a way of using memory to maintain the picture. Visualization refers to techniques of mentally tracking aircraft through a wide airspace, anticipating any decisions, orders, or problems that might arise. (See section 4.3 for more discussion of visualization.) In all, about 40 percent or two out of five controllers report personal techniques (not memory aids) when asked about how they use memory on the job. Their approach indicates an emphasis on knowing all phases of ATC and places an extremely high priority on keeping one step ahead of the traffic flow.

b. Memory Aids. Controllers report using 29 different types of aids. Strip management, or the arrangement of flight progress strips in a logical manner, was the aid most controllers report using. Strip management in Air Route Traffic Control Centers (ARTCCs) is a mandatory procedure since two or more controllers (R & D) usually share the same information. In most cases, the Radar Controller (R) gives the actual clearances to the aircraft and the Associate Radar Controller (D) does the strip arranging or marking.

Terminal controllers use the strips as a back-up to their radar presentation and usually arrange their flight progress strips in one of two ways:

a. Top (most recent) to bottom (ready for hand-off) order

b. Bottom (most recent) to top (ready for hand-off) order.

The ordering is determined by the controller's preference and can vary among controllers working the same shift.

Cocking (or tilting) a flight progress strip to indicate that further action is required, is another memory aid that controllers frequently mention. The angle signals attention to the strip, making it stand out within the strip bay. Controllers develop their own specific ways of using cocked strips as memory joggers, e.g., cocked left means aircraft is pushing back; cocked right means the aircraft is awaiting taxi instructions. Cocked strips seem to be the preferred method to indicate that further action is needed.

Controllers tend to view the requirement for record-keeping by marking strips as a necessary evil which they would rather eliminate. The survey indicates that about half of the controllers (49 percent) volunteer that they use the procedure. (See table 3-5.) However, most controllers admit that when they are busy (and when accurate strip marking is most critical) this memory aid is the first thing that they eliminate.

Most controllers indicate that they do not have enough time to simultaneously control aircraft, type entries into a computer, and write instructions on a flight progress strip. The exceptions to this prevalent opinion come from some of the most experienced controllers who feel that the importance of having a back-up system to reduce reliance on their memories is centrally important. These controllers have incorporated strip marking into their scanning of the radar scope. They feel that those who do not use such a system are improperly trained and rely too much on radar for information. They believe it is a mistake to rely solely on the screen to accomplish ATCS tasks.

Controllers report familiarity with various types of software designed to reduce reliance on memory. Computer programmers, acting on suggestions from the controller work force, have provided a variety of aids or memory joggers. In particular, two out of three (66 percent) of the ARTCC controllers report using the "J" ring or ball; this refers to the controller placing a 6-mile halo around aircraft on his or her screen. Controllers are less likely to use other similar types of software aids. When one controller was asked why he doesn't use such software, he replies that it is for "rookies" and he doesn't need it. Another controller says he feels a reluctance about using memory aids because he thinks his peers will regard him as a "weak sister." This attitude is prevalent throughout the system except in those facilities where the use of particular memory aids are standardized and application is mandatory for all controllers.

3.3.1 Backup Techniques.

Controllers explained how they worked radar with strips; in particular, how they kept the strips updated. Of the 170 controllers, 30 were either in non-radar training, were from facilities that do not have radar, or in a facility that does not use strips. Table 3-6 gives the techniques that controllers report; most controllers interviewed (119) are currently writing and talking simultaneously. **Some facilities mandate that once a clearance is issued, the next step is to write and type the information while listening to the pilot read back. At these facilities, instructors stress strip marking as an intricate part of position certification. This approach produces a controller who is trained to write clearance information on the flight progress strips and to make the necessary computer entries as a procedural steps necessary to "complete the transaction." These procedures become part of the controller's standard operating procedure.**

Most (three out of four) controllers report being trained to use the technique of C-T-R-W or "Clear and Type, Read and Write." This is controller jargon for "when you issue a clearance to an aircraft or other controller, you type the information into the computer; when you receive the read-back, you write that information on the flight progress strip."

TABLE 3-6. TECHNIQUES TO KEEP STRIPS UPDATED

Techniques	Number of Responses
Talk and write simultaneously	119
No special techniques	14
Strip mark as little as possible	4
Use strips as little as possible	3
Not applicable	30

Q.6. Initial Interviews and Q.8. Revised Version: "When working radar with strips, what techniques do you have to keep the strips updated?"

Individuals at facilities that stress the C-T-R-W system are maintaining a back-up system. They keep up with their strip marking, even when traffic conditions get intense. Other facilities, while realizing the importance of strip marking, place less emphasis on keeping the strips current during training. Supervisors allow developmental extensive latitude in when they mark their strips. Controllers are allowed to transfer information when they feel they have the time; or they may elect to have their "D" side (Associate Radar Controller) update their strips as a routine function. These controllers tend to de-emphasize the strip marking when they get busy and regard it as a crutch "that the older guys have to use."

The interviewer also asked controllers a related question to determine if controllers had developed any note taking or marking conventions that would augment or replace strip-marking as a way of dealing with short term memory constraints. A few controllers say that they use a note pad or write information on the radar scope with a grease pencil. A few more report variations on facility strip-marking procedures.

For the most part, controllers are trained that their primary role is to scan the radar scope. They view the record keeping chores as secondary in nature to their "real" task. A minority of controllers regard strip marking as a "hassle" at any time and would prefer that they not have to use the system at all.

3.3.2 Use of Techniques and Aids Under Busy Conditions.

Having asked about the techniques and aids that controllers used, the interviewer then asked controllers to describe their use of techniques and/or memory aids under extremely busy conditions. The objective was to see if controllers were more or less likely to use the reported techniques or aids under extremely busy conditions. Table 3-7 presents the techniques that controllers report that they use under busy conditions. Table 3-8 shows the memory aids that controllers report using under such conditions.

As the aircraft workload increases, the tendency of most controllers is to focus attention to the radar scope or traffic pattern and to place the highest priority on constantly scanning, reviewing, and mentally updating the traffic flow. In general, controllers regard the self-reliant controller as someone with the ability to shut out all outside distractions, work within the confines of his or her airspace, use minimum words, and give precise instructions. In short, more emphasis is placed on keeping the "big picture" through intense concentration and reliance on short term memory than on the use of memory aids or on joggers to provide a reliable back-up system.

With the exception of strip marking (47 controllers or 28 percent) and strip board and note pad management (39 or 23 percent), all other memory aids received limited references in terms of use under busy conditions. (See table 3-8.) The perceived workload involved in using these aids seems to be the main deterrent to their consistent use. For the most part, respondents using these aids on a routine basis were ARTCC controllers. Most terminal radar facilities, due to equipment layout, training, and prevailing attitudes, rely entirely on their Automated Radar Terminal System (ARTS) displays. A few facilities have done away with written strips entirely. The tendency is to focus all attention on the scanning of the radar scope regardless of the volume of traffic involved or of the burden placed on short-term memory. The reasoning is that distractions caused by moving from radar scope to flight progress strip are minimized.

TABLE 3-7. TECHNIQUES THAT CONTROLLERS USE UNDER BUSIEST CONDITIONS

Techniques	Number of Responses
Intense scanning, concentration, review	46
Rhythm, consistency, standardization of instructions	25
Preplanning, forecasting traffic flow	20
Clear, concise instructions; control of frequency, good listening skills	20
Issue prioritized control instructions	19
Stick to basic air traffic control, adhere strictly to procedures	18
Initially complete the transaction	7
Simplify the operation, minimize transmissions	6
Visualization	5
Association (strips cross-checked with data tags)	4
Reliance on radar associate, peers, or supervisor	4
Be mentally prepared	3
Eliminate distractions	2

Q.4. Initial Interviews and Revised Version: "As your workload increases to the point where you are really busy, which of these techniques do you use and how do you go about managing your workload?"

TABLE 3-8. MEMORY AIDS THAT CONTROLLERS USE UNDER BUSIEST CONDITIONS

Memory Aids	Number of Responses
Strip marking	47
Strip Board Management, including cocked strips (center)	39
Note pad management (Towers)	17
Reliance on all automated features/presentations	9
Off-set data blocks	8
Need all of the available aids	7
"J" Ring/ball (Center)	7
Cocking strips	5
Status boards/note pads/grease pencil markings	4
Leader lines as indicator of direction	3
Vector lines	3
Limited data blocks as traffic volume indicator	2
Timeliness of computer entries, radar history, CRD/ display	2 (each)
Slant/0, interim altitudes, arrival drop lists, time share software, speed control, blank strip	1 (each)

Q.4. Initial Interviews and Revised Version: "As your workload increases to the point where you are severely busy, which of these techniques do you use and how do you go about managing your workload?"

3.3.3 Scanning: Memory with Scope/Strips.

Currently, there is no established scanning technique taught to controllers. Each develops his or her own approach. (See table 3-9.) The most frequently mentioned strategy involves watching the sector center from the airport out to the edge of the scope. Controllers mention several other strategies, including a technique involving no set pattern of approach.

TABLE 3-9. SCANNING STRATEGIES WHEN WORKING A RADAR POSITION

Strategies	Number of Responses
Airport out/sector center to outer edges of scope	62
Hot spots (according to traffic flow)	38
Clockwise (follow the sweep rotation)	29
No set pattern	24
Outer edges into center of scope (airport)	21
Not using radar yet	10
Counterclockwise	8
Entire scope (top to bottom)	4
Airway to airway	3

Q5. Follow up in Initial Interviews and Revised Version: "Probe here for scanning strategy . . ."

The interviewer asked controllers: "When working a radar position or local control position with BRITE radar, to what degree do you rely on the alphanumeric display to keep your memory current"? The interviewer probed for a description of scanning strategies or techniques. Their answers appear in table 3-10.

TABLE 3-10. EXTENT OF RELIANCE ON DISPLAY DATA WHEN WORKING RADAR POSITIONS

Extent of Reliance	Number of Responses
Heavily, quite a bit, a lot, to a great degree; or 75% of the time or more	141
Half the time; or 50% - 70% of the time	11
Less than half the time	3
Not applicable	15

Q5. Initial Interviews and revised version: "When you are working a radar position to what degree do you rely on the display data to keep your memory current?"

The interviewer also asked controllers to indicate how important strips were to their overall operation. (See table 3-11.)

TABLE 3-11. RELATIVE IMPORTANCE OF STRIPS IN WORKING RADAR

Relevance	Number of Responses
Very important (cross reference) use 50% or more of the time	23
Used for preplanning, as memory jogger, backup: 25 to 49% of the time	73
Occasionally use strips (record keeping)	29
Little or no use of strips; less than 15% of the time	16
Not applicable	29

Q.5. Follow up in Initial Interviews: "Probe here for scanning strategy and attempt to identify the relative importance of other source of information, i.e., strips and other displays." Probe was used in Revised Version also.

Alphanumeric readouts, whether located at the ARTCC, Airport Surveillance Radar (ASR), or Tower Cab Bright Radar Indicator Tower Equipment (BRITE) displays, are the first choice of controllers for keeping memory current; 141 out of 155 (91 percent of the respondents) report using alphanumerics more than 75 percent of the time. (See table 3-10.) Controllers rely on the displayed data to show aircraft position, altitude, speed, and direction. Since they have these data available at eye level, they believe they have no need to turn away from their scopes or traffic pattern to make a written entry on a flight progress strip or pad. Only about one in eight controllers report that use of strips is very important in working radar. (See table 3-11.)

Controller dependency on automation was noted by The Mitre Corporation in the 1970's (Kinney, et al., 1977). They reported that controllers used recall memory to give control instructions using only displayed data and unsupported by note-taking, note references, or other memory joggers. Overuse of automation or equipment dependency accounted for over 39 percent of the total system errors analyzed in the PERI first-year report (1990) for the years 1984-1986. The results of this current survey of controllers indicate that this trend continues.

3.3.4 Remembering Infrequently Needed Information.

The interviewer asked controllers to describe the techniques or methods they use to keep from forgetting important information that they use infrequently. Their responses appear in table 3-12.

TABLE 3-12. METHODS OF HANDLING INFORMATION USED INFREQUENTLY

Methods of Aids	Number of Responses
Sector binders, position charts, overhead displays, status boards	134
Systems ATLANTA and other video presentations, e.g., IDS, DDS, VDS	55
Other note keeping or facility organized display list	26
Peers or supervisors	9
CRD display, computer scratch pad	5
Not applicable	6

Q.9. Initial Interviews and Q.10: Revised Version: "How do you keep from forgetting information that you must know but use infrequently?"

Most controllers (134 out of 170 or 80 percent) report using sector binders, airspace layout, and/or sector airways maps -- whether on overhead radar scope presentations or under plexi-glass covered work stations -- as their main source for infrequently used information. Most controllers felt that they could obtain any information that they desired but that the process was distracting and took their eyes away from their primary scanning functions. Many complained of the poor lighting on the overhead displays, the improper positioning of displays, and the added work involved in obtaining the needed information.

One out of three controllers (55 out of 170 or 32 percent) report using information storage devices such as Systems ATLANTA, although these systems are not installed at all the facilities visited. Controllers have the following complaints about such systems: the location of the equipment is poor, viewing is distracting and takes the eyes away from the primary scanning functions; the angle creates difficulties in finding the right page of information; the operator must make multiple entries in order to gain access; most lack color or differentiating hues to distinguish types of information; the monitors are either too small or too large; operators cannot obtain all of the needed information on satellite airport operations, flow restrictions, or individual air line problems; and, overall; there is no guarantee that all new information is entered in a timely manner.

With few exceptions, most facilities rely on the Read Binder system for updating controllers. This system has been used since the earlier days of flight controlling as the standard method for exchanging new information and reviewing old procedures. This system requires that the controller read information that is contained in a binder. The ATCS then initials next to his or her name to indicate that he or she has read the information. The problem with this approach is that information gets misfiled; frequently, controllers do not see the information in a timely manner.

One of the facilities that is an exception to the traditional Read Binder approach has a Systems ATLANTA monitor installed in the break room, next to the facility sign-on log. The first page is devoted to a capsule description of upcoming or recently implemented revisions, changes or outages; in addition, this application provides references to additional information. It is mandatory that each controller read through the changes prior to signing on.

Some facilities currently use binders or a series of plasticized pages on an O-ring because they have no computer for a data base like Systems ATLANTA. One of these sites uses a position-specific set of indexed cards to keep "need to know information" at the control positions. This system makes it easy to access information since all data in this alphabetized file are available with the flip of a finger.

At ARTCCs, controllers rarely use the Computer Readout Device (CRD); five controllers cite it as a source of information. This video monitor could serve as a major source of information on the flights under an individual controller's command but it did not receive the recognition expected for it.

3.3.5 Standardization.

About 15 percent of the controllers indicate that the main technique they use when their workload increases is to standardize their instructions. Another 11 percent rely on strict adherence to procedures -- another form of standardization; three out of four controllers use other techniques to maintain situation awareness. (See table 3-7.)

Many controllers are unaware of the advantages of standardizing control techniques and work habits and then adhering to these standardized processes regardless of traffic volumes. Some lack of awareness is related to overestimation of their memory processing systems, especially short term memory and overall memory capacity. Many rely on recall memory (the reference to remembering something without note taking or using memory joggers) which can be highly unreliable when outside interference is present.

3.3.6 Other Equipment, Aids, or Suggestions.

Controllers were asked if they had suggestions for improving the current system to make it easier to remember essential information. Most of them do not have suggestions for improving the system in terms of remembering essential information. They did, however, have ideas about changing the system and their responses often deal with finding solutions to their own personal issues. Their suggestions fall into four categories: changes in training (covered in section 3.4), changes in procedures and rules, ideas on equipment, and a miscellaneous category. The suggestions follow:

Procedures and rules.

Eliminate altitude shelves
Keep sectors opened, using more staffing
Minimize frequency of changes in rules
Standardize procedures; eliminate gray areas
Change the Air Traffic Procedures (ATP) manual to reflect traffic conditions
Cut down on manual size, eliminating extra rules and restrictions
Allow time for proper relief briefings
Eliminate strips
Reinforce good habits and good techniques
Rethink dynamic simulation (DYSIM) scenarios

Equipment.

Update the equipment
Simplify the keyboard entries
Put information display boards at centrally located positions
Increase the speed of updates for computer information
Have adjustable beacon code sizes
Improve overhead displays
Improve transmitters and receivers

Other suggestions.

Improve the lighting
Get better advanced warning systems
Minimize distractions; sector noise levels
Balance schedules with body rhythms.
Enforce a higher degree of preparedness and professionalism
Encourage more networking between ARTCCs.
Eliminate the isolation now associated with being an autonomous unit
Teach course on "how to remember"
Teach better methods of organizing information
Teach course on effective listening
Make controllers, as well as supervisors, accountable for their actions

3.3.7 Automation Concerns.

Controllers were asked if automation is the answer to various concerns they have; there were a range of responses with the most frequent being a request for more automation and more automated aids. Controllers requested:

More automation and/or more automated aids
More color coding or colorization of scopes

Better presentation of current automation, including better prioritization
User-friendly automation
Window displays for additional information (not another scope)
Less computer redundancy

New systems under development, such as the Advanced Automation System (AAS) and Automated En Route Air Traffic Control System (AERA), may fulfill some of these requests. At the same time, some controllers feel that there is already too much automation, expressing concern about the impact of impending change. While ARTCC controllers know about the forthcoming AERA-2 system, now under design, they are unfamiliar with its details and features.

The majority of controllers interviewed like their work and indicate that they try to improve their performance. But many view automation as a possible threat to decision-making options; they feel that they may be only a few years away from being a passive monitor to a highly sophisticated system. They wonder if eventually they may be replaced by machines. One of the most experienced ARTCC controllers sums up this type of concern: "If the FAA thinks they have problems with boredom and system errors under light traffic conditions now, what do they think will happen in the futuristic system when we become typists rather than problem solvers"? Such concerns reflect a lack of understanding of the current direction of automation efforts which will still leave the ATCS in control. More education and familiarization may help to reduce these concerns.

3.4 LEARNING THE JOB: TRAINING ATCSs.

The air traffic controllers describe various types of training they received at the Academy, in classrooms at the job, and through other types of on-the-job training. Most of the controllers report that no one teaches the ATCS how to use memory in any phase of training; as trainees they had to learn to use their memory on their own, using techniques of repetition and association in rote procedures. The ATCSs report that their real learning comes on the job; and here they have a wide range of suggestions for ways to facilitate the on-the-job learning process.

3.4.1 At the Academy.

Most ATCSs report that they were not taught any particular techniques to manage memory beyond rote memorization, a technique they were encouraged to use at the Academy. The ATCSs cite examples of how they did this rote learning; many report using flash cards by themselves or as part of a group. Two controllers reflect recent changes at the Academy: one controller mentions reading a booklet on memory (probably the Controller Memory Handbook) and another mentions attending a course on memorization at the Academy.

In further describing the process of rote learning, the ATCSs report using repetition as a technique. Some report that they break a large amount of information into smaller pieces and learn one piece before moving onto the next. Some describe using association processes

involving acronyms and mnemonics. They mention highlighting of more important text. Some controllers say they used questions and answer sessions with other students or a tape recorder.

Some ATCSs characterize their experience at the Academy as one in which they felt harassed as students rather than one that helped them to learn. One ATCS says that he faults the Academy for a philosophy of teaching to tests, rather than a more inclusive and possibly a more time consuming approach of explaining the reasons and background for a given method of practice. ATCSs express a desire for more interesting and relevant "hands on" experience to supplement handbooks and classroom lectures. One controller states that a prebriefing, to establish the goals of a training session, is an effective way for him to get more involved in the content of the session. New screening methods and a revised teaching philosophy scheduled for implementation in the Spring of 1992 may resolve many of these issues.

3.4.2. In Facility Classrooms.

The ATCSs were asked to describe any training they had received in facility classroom settings to help to manage memory. Most said they had no such training. Instead, they describe learning by use of rote procedures which, like learning at the Academy are based on repetition and association and involve flash cards, highlighting, breaking "wholes into parts," and listening to tapes.

3.4.3 On-the-Job Training.

Controllers describe various on-the-job training experiences, including radar training and training to become position qualified.

a. Radar. Most ATCSs report that their radar training using enhanced target generator (ETG) and DYSIM equipment provided the basics but that they are not realistic enough. They say that scenarios are not changed often enough and that they need more options, more randomization, more realism, and a faster pace. No one reported any particular instruction related to memory retention specific to the use of radar equipment.

b. Becoming Position Qualified. Most ATCSs report that they became position qualified through one-on-one instruction. While some controllers believe that only one instructor should do initial training, the consensus is that this phase of training is best handled by a small core of instructors working with the trainee.

ATCSs say that the instructors should want to teach and should be drawn from the older and more experienced controllers. Some suggest that instructors should be screened for traits of patience and consideration; furthermore, they believe that instructions should be subject to evaluation themselves.

Some ATCSs suggest approaches to training that they found helpful. One describes a session having a prebriefing to set goals, followed by a "hands on" lesson, and then a debriefing. One ATCS recommends a four-step approach to on-the-job training:

1. Break material into small units

2. Discuss the procedures and demonstrate the equipment, i.e., show and tell

3. Present an up-to-date video, covering the material demonstrating procedures and equipment in a working context

4. Hands-on experience.

Some ATCSs report learning during training that they could not rely entirely on their memory and that they would have to use notes and other memory joggers. Examples of these joggers are indicators for: runway closures, runway crossing, navigation outages, geographic location on video maps, and strip marking as a record keeping device. A few ATCSs mentioned techniques of handling aircraft that result in reduced reliance on memory. These techniques include: prioritizing clearances in order of importance, adopting "standardization" techniques that treat most aircraft and activities as similarly as possible; and initially "completing the transaction," that is, communicating or structuring an interaction so that no unfinished business remains for attention at another time.

Many ATCSs say that they learned the most from their on-the-job training because it gave them the hands on experience that they felt they lacked. Some receive additional experience by working on the midnight shift when traffic is lighter than normal; more time can be spent explaining control techniques. One controller suggests that developmental should start at low density facilities, levels 1 and 2, before moving to higher density facilities, levels 3 - 5. Such an approach evidently has not been possible, due to personnel vacancies at the larger facilities.

c. Other Resources. Some facilities have libraries with FAA or other videos and manuals for self-instruction. Some of these sites have developed their own training materials. However, when this has occurred, other facilities are not aware of this material. Conventional procedures often vary within a given facility, e.g., type of pad used and the notation employed. Procedures frequently vary from one facility to another. To help the newcomer, one facility produced a manual describing the local area, key contact people, and other vital information. Academy graduates found this manual particularly helpful.

Limited networking goes on between facilities concerning the topics of education and training of ATCSs. One relatively recent exception to this generalization is the program, Controller Awareness and Resource Training (CART). CART is a 3-day seminar for ATCSs; the topics covered include interaction among controllers and pilots and the effect of human factors on the judgements of ATCSs and pilots. The focus is on interpersonal skills rather than on "controlling." The topics covered concern human factors that can affect memory and job performance. Specific discussions cover "problem-solving, identification of resources, distractions, attitudes, stress, anger, judgement, communications, situational awareness, time

management, incapacitation, and conflict resolution." (Henderson, 1988) (A similar FAA-sponsored program began in the fall of 1991. As an outgrowth of this prototypical program, teaching materials and standards will be developed for air traffic personnel.)

3.4.4 Self-Teaching and Memory Training: On and Off the Job.

The ATCSs report doing extensive amounts of self-teaching during their careers. However, they regard this as part of learning the job and not as a form of developing facility for retaining information in memory. Their self-teaching usually involves written material, using the techniques based on the principles of association and repetition to learn the content. As previously noted, these ATCSs use association techniques such as flash cards, group study, and audio tapes to learn the material.

Most ATCSs say they do not use memorization techniques off the job, for example, to remember telephone numbers, PIN codes, family birthdays, or anniversaries. One former musician, however, says that the principles he learned for memorizing music for performances are applicable to learning information related to ATC. He describes the process as starting with a small section, learning that portion, going on to the next section, and then rehearsing the new section along with the previously learned portion. When it comes to remembering material when off the job, ATCSs report that they write down necessary information. Like the rest of the world, they make lists and use planning notebooks.

The concern about training that controllers express most frequently is that developmental need more experience on positions for which they were certified before they move on to the next training position. Other suggestions are:

Limit interruptions in training
Use site-specific scenarios at the Academy
Provide more review time
Give more recurrent training, i.e., give a simulated radar problem for currency
Incorporate training on standardization
Allow more in-depth training
Design training manuals around actual use
Teach proven techniques and make everyone adhere to the procedures.

4. CONCLUSIONS.

Controllers at facilities all over the country are aware of various types of memory aids. These memory joggers are available at the facilities so that controllers could minimize their current heavy reliance on short-term memory by using them. However, the prevailing attitude among controllers, an attitude reinforced by many in management, is that most memory aids are crutches that only the weakest controllers use. Furthermore, controllers are less likely to use memory aids when they are extremely busy. Most controllers report using strip marks for flight progress strips, under normal or light traffic conditions. However, under busy conditions only

one in four controllers strip mark. Instructors, who have limited or no training in memory capacity, pass on this negative view of memory aids. They insist that developmental learn, generally by rote, what the instructor has learned over a period of years before recommending the trainee for certification. This attitude towards on-the-job training, in effect, leads to training individuals the same way they were trained 40 years ago.

This situation will be difficult to change. To convince controllers that they should incorporate a back-up system, regardless of the traffic situation, will require major retraining and changes in attitudes among some of the most experienced controllers. Newer controllers learn both formally and informally from the more experienced controllers; they tend to follow the examples they see on the job.

4.1 THE EFFECTIVE AND OUTSTANDING CONTROLLER.

Every controller interviewed could discuss the characteristics of an effective or outstanding controller. Controllers hold these colleagues in high regard. Memory and concern for safety may be implicitly associated with the top traits that controllers associate with an effective controller but they are not explicitly associated with the "outstanding" controller. Most air traffic control specialists (ATCSs) do not mention a good memory as a characteristic of an outstanding controller nor do they mention a concern for safety. About two in five mention specific techniques associated with the best controllers, e.g., standardization, or working principles such as initially "completing the transaction." These techniques have the effect of minimizing demands on short term memory.

About one in five of the ATCSs mention team work (with their coworkers and sometimes with pilots) as an attribute of an effective controller. This approach may, in effect, distribute the memory load. Some research indicates that over-reliance on the model of the self-sufficient controller can lead to misjudgments and errors (Henderson, 1988). In contrast, where cooperation and team work are the norm, a controller who detects a potential problem will feel free to mention this situation to another controller.

4.2 STANDARDIZATION.

The topic of standardization in the Air Traffic System is not a new one. The Federal Aviation Administration (FAA) is well aware of the merits of the approach and has initiated many programs associated with standardizing the National Airspace System (NAS). Examples include: one-way airways to reduce opposite direction traffic, metering based on airport acceptability to eliminate unneeded holding at lower altitudes, Standard Arrival Routes (STARs), Standard Departure Routes (SIDs), profile descents for fuel economy, and airspace conservation.

Standardization may be the most efficient way for a controller to increase his or her capacity to control traffic flow safely and efficiently. Standardization allows the controller to treat 10 aircraft as 10 examples of the same situation, that is, on the same route at the same speed, separated by the same distance, and flying at the same airspeed. This routinization and

homogenization of activity is an example of "chunking," that is, placing items into familiar units or chunks and recalling them as one entity. Chunking can increase memory capacity and, by doing so, may reduce errors due to memory overload.

According to the controllers interviewed, standardization techniques can minimize the chances of a system error or deviation occurring. When the study participants describe outstanding and effective controllers, they repeatedly mention characteristics such as preplanning, prioritizing, or initially "completing the transaction" which stress consistency and standardized techniques. Such techniques minimize routine judgement required by controllers. They also provide known guidelines for many circumstances and increase predictability for controllers. They cut down on controller errors by providing consistent and readily accessible rules for handling information and tasks.

One controller describes the benefits of standardization as allowing the mind to retain information in an organized and efficient manner. Repetition of constantly used phrases in a routine manner frees the mind of the chore of searching for a new solution for routine occurrences. Using a standardizing approach, each controller position gets allocated airspace for the performance of control tasks. Standardization for climbs and descents minimizes coordination necessary to expedite aircraft movement. Also, climb and descent corridors make it easier for other controllers to keep aware of the potential conflicting traffic. The approach of standardization cuts down on errors due to a controller assuming separation and or as a result of controlling aircraft in another's airspace.

Standardization of phraseology minimizes the chances of a system error or deviation because of miscommunication between pilot and controller. Standardization of strip marking minimizes errors due to a misunderstanding of written information. Lack of appropriate strip-marking forces reliance on recall memory which is highly susceptible to distraction and place a burden on memory processing.

Standardized use of flight progress slips in a logical, organized manner allows other controllers to obtain system awareness (to get the picture) quickly and accurately. This process enables control supervisors to oversee the current operation, assess the traffic flow, act as another set of eyes, or, if necessary, to assist the controller in his or her activities.

Standardization reduces reliance on recall memory which is most susceptible to interference from distractions, momentary diversions in the thought process, preoccupation with other unrelated subject matter, lack of sufficient mental stimuli, and the passage of time. All these interfering factors are associated with system errors, particularly under light to moderate traffic volume.

One of the facilities visited on this survey had one of the highest rates of system errors for terminals in a recent reporting period. An FAA evaluation team recommended changing procedures and restructuring airspace configuration. Although facility personnel initially offered resistance to this change, the end result was to reduce the number of errors to the lowest total in the FAA in the following year. Controllers were allotted segregated airspace, descent areas, and vectoring corridors. Airspeeds had to be controlled, vector headings were narrowed to coincide with vectoring corridors, and a more organized method of handling large volumes of

traffic followed. Controllers, who initially resisted change, now are advocates of the uniform approach and agree that, by standardizing the manner of each task, their job has been made more manageable.

4.3 VISUALIZATION.

A small percentage of controllers (3 percent) are aware of relying on visualization or mental imagery to keep track of their workload. These controllers envision the projected routes of all flights. Their scanning strategy includes using limited data blocks as traffic indicators, looking at least 15 to 20 miles outside the geographic limits of their airspace to plan their activities, cross checking by using flight progress strips to confirm route of flight and altitude, and then mentally seeing the flight's progress through their airspace.

By visualizing the flights' projected routes, controllers mention that they can group certain flights together because they know they are at the proper altitude, sufficiently spaced, and in no danger of conflict with other traffic (i.e., standardized). They are then able to pay less attention to these aircraft and to devote more time to the aircraft that they feel need their assistance. A key factor in using visualization as a traffic flow forecaster is that these controllers are able to project well in advance the need for assistance and are able to ask for help before they get saturated. In other words, they work proactively rather than reactively. Controllers who use visualization say that once they determine that the possibility of a conflict exists, they immediately take care of it (i.e., they initially "complete the transaction" when they become aware of it). This approach allows them to reduce their work load by reducing time spent in intense scanning.

A supervisor with over 30 years of experience explains why he uses this particular memory technique. He says that by using visualization he is programmed to accept the hand-off. He knows who he will be talking to; he knows whether or not any control action is necessary and, as a result, he has never had any surprises to distract him from his scanning technique. In his years of active control, he has never had a systems error and has no intentions of retiring. He compares visualization of an aircraft on a projected route to driving a car from home to work. He has a mental picture of the road ingrained in his mind so that he need not refer to a map in order to find his way. He applies the same strategy when he works traffic. He claims that he has stayed with controlling for so long because he "keeps it simple" and adopts an approach of letting the pilot work with him.

4.4 THE FACILITY.

Distractions in the work site, diversions in thought processes, and other interference contribute to unsatisfactory performance of controller tasks. There are many sources of distractions, including controllers themselves and various aspects of the work environment.

4.4.1 Distractions in the Facility Environment.

One major source of distraction is non-task related conversation. Controllers are extremely bright people and, like employees anywhere, they report that they enjoy non-work related conversations with their colleagues. Often controllers talk about past or future social activity or about sports when working light to moderate traffic. They discuss or debate the relative merits of professional teams, engage in arguments in and around a work station, even as other controllers are working. During such a discussion, other controllers in the room may divert their attention from traffic patterns and ground movements to "take a side" or simply to pay attention to the discussion. Supervisors frequently join in this behavior themselves.

Controllers describe how such distractions may lead to errors by creating the following types of situations:

Inattention to control tasks

Read-back instructions being more difficult to understand

Message repeats due to noise interference

Raising the voice level while delivering a message, tending to increase the noise level in the control room

A build up of frustration, leading to a loss of patience.

As one supervisor suggests, staffing requirements make it difficult to combine positions but, on the other hand, he has met criticism for allowing extra bodies to fill up the break room and idly pass time at government expense. He feels that, at times, he has a team of bored controllers who, under the best of circumstances, have difficulty concentrating on the reduced traffic flow. Boredom, as previously noted, is associated with system errors. As the results of the interviews indicate, the majority of controllers and supervisors recognize that boredom is a serious problem.

4.4.2 Distractions that the Controller Brings to the Facility.

During the interviews, controllers say that they try to keep personal and family problems away from the job but that they are not always successful in doing so. Common causes of problems affecting job performance and memory are anxiety, fatigue, stress, grief, and mild depression. In addition, an illness, isolation, habitual inactivity, and excessive use of alcohol can all induce memory loss. (The Johns Hopkins Medical Letter, 1991)

4.4.3 Uniformity at a Facility.

Some controllers and their supervisors express a need for a standardized manner of information transfer so that no misunderstanding exists when exchanging essential data among themselves. For instance, the random use of abbreviations, known only to an individual controller, serves no practical purpose to a supervisor trying to oversee the operation who may have to assist that individual controller.

4.5 LEARNING PERSONAL AND SITUATIONAL LIMITS.

Controllers tell us that they often learn about their on-the-job limitations through making a mistake; then, as a result, they begin to do their work differently. They receive limited or no instruction on such matters as learning one's memory limitations, increasing memory capacity, chunking techniques, reducing stress on the job, eliminating environmental distractions, minimizing reliance on short term memory (STM) through use of memory aids, and coping with boredom.

Many controllers say that they do not know how to cope with boredom on the job. This is also an area where controllers do not receive any guidance from top management. Supervisors feel that they are caught in a bind; they are told to staff low volume positions at normal staffing levels; however, this policy creates a low workload and subsequent problems with boredom.

In the present ATC environment, controllers indicate that a great deal of emphasis is placed on the reduction of system errors through the changing of procedures, restructuring airspace to minimize opposite direction traffic, metering traffic flow, developing climb and descent corridors, and putting reliance on automated aids. Such procedures are necessary to help controllers cope with heavy volumes of traffic in a routine manner. The standardization of the NAS system has reduced errors where heavy volumes of traffic are concerned. However, 70 percent of system errors occur under light to moderate traffic conditions. Rather than changing procedures for light to moderate traffic, more emphasis on changing work habits and attitudes may be required. As the survey of controllers indicates, most controllers place almost exclusive reliance on automated data, without using any back-up system.

4.6 TRAINING.

In drawing on what the ATCSs said during this series of interviews, it is clear that controllers believe that there is room for improvement in the training that they receive. Controllers say that developmentals need more time to learn positions completely; they complain that they need more information on aircraft characteristics and performances and more information on what pilots face and what pilots or their planes are capable of doing. The ATCSs want more relevant training in up-to-date labs, using videos, manuals, and computer based simulations that reflect current technology and environments. They want additional training on listening and learning and they feel that more attention should be paid to picking and training instructors, at all levels.

Controllers are receptive to automation, but they have many questions about how an increasingly automated environment will affect their life and work. To effectively introduce new approaches, controllers will require training that involves thorough explanations of the factors that go into computer decisions. In effect, the controllers want to know and to understand all the factors that go into the formulation of the resolutions of problems covered by the highest ranked resolution (HRR).

5. RECOMMENDATIONS.

The memory aids to enhance controller memory exist; more research is necessary to understand under what conditions controllers will use them. Similarly, controllers admire their colleagues who demonstrate techniques associated with preplanning and organizing work. Again, the Federal Aviation Administration (FAA) needs to know how controllers can learn these techniques effectively and under which working conditions controllers are more or less likely to use these techniques.

In the course of the in-depth interviews, controllers made several excellent suggestions about alternative training procedures and approaches to training; their recommendations appear below. Finally, there is a need for creation of a centralized information gathering body to make the information already in existence, particularly information about training, available through the FAA system.

5.1 CREATING ENVIRONMENTS THAT SUPPORT USING MEMORY AIDS.

5.1.1 Introducing Memory Aids.

Since human beings tend to resist any changes to the current operating environment where they are comfortable, the task of developing new, innovative memory aids or making changes in the current system, will be complex. In order for controller acceptance to take place, any newly recommended aids will have to be easy to use, second nature in application, and require minimal time away from scanning of the radar scope or of the traffic pattern/ground movement area. Furthermore, many controllers feel that aids can not be "mandated." They resent being closely managed, believing that this takes away from the individuality they feel that each controller must have to perform the job. Therefore, to foster adoption of memory aids, a "need to use" atmosphere must exist. Research on the optimal design of the aids, on effective training to introduce these aids, and on the correlates of successful adoption of aids will be essential.

The research findings show that, where appropriate, most controllers use strips, at least occasionally. An effective approach to encouraging use of aids should start with this aid that most controllers already consider trustworthy. Additional research can determine how controllers might make even better use of strips, e.g., using strip bays more effectively or developing strip marking techniques that ATCSs will use under all circumstances. Controllers cited strip marking as a useful memory jogger, but its contribution has not been experimentally tested. Research is also needed to determine optimal equipment layouts for specific sites.

Current layouts and concomitant distractions make it difficult to use strips effectively at some sites.

Controllers are visually oriented and seem to prefer visual aids over other types; they claim that audio aids are a distraction. Controllers rely heavily on scanning; it is the main technique controllers have of keeping current with the traffic flow, whether through visual observation of the traffic patterns or ground movement area or by continually reviewing their radar scopes. Since scanning is an individual technique that does not appear to have one clearly superior application, controllers will benefit from being aware of the variety of techniques that exist for scanning as well as the strengths and weaknesses of each technique under various circumstances.

5.1.2 The Facility Environment.

Various aspects of the facility environment have an effect on controller memory. Traffic patterns and related staffing practices lead to slow periods. Almost all controllers report experiencing boredom at some times on the job and they describe various distractions caused by controller inattention or by conversations that can create situations leading to systems errors. Since boredom appears to be a common precursor of errors, there is a need for further research to determine both the circumstances producing boredom as well as strategies that managers and controllers can use to cope with it.

One of the ways of making work demands more manageable involves use of standardized techniques. These techniques are one example of instituting uniform operating procedures at a facility. There are various other practices at facilities that merit review to see if adoption of uniform procedures would be beneficial, for instance:

a. Strip board management in ARTCCs where specific methods related to keeping track of aircraft movements and amendments (e.g., via cocked strips) need close coordination between manual and radar controllers.

b. In towers that use note pad management instead of strips, all controllers should use the same conventions for their notations.

c. In the use of software or techniques designed to reduce reliance on short term memory, the conventions indicating current status of an aircraft should be uniform.

Many aids currently in the field, such as SLANT-ZERO for communications transfer in ARTCCs or ARRIVAL DROP LISTS which inform the tower ground controller of the last three to six landings, are currently under-utilized. Also, there is no uniform manner or suggested approach for using software patches, with the result that there are many local adaptations. Facility managers, with the concurrence of their facility advisory boards and the unions, have the latitude to select or reject the information patches that are available. In many cases, software patches are not used. This seems to be a direct result of not having current information available, due to a lack of networking to disseminate software data bases.

In addition to on-site circumstances that affect controller memory, controllers bring a host of problems with them that can interfere with their ability to work. Current Department of Transportation policies provide for random tests of drug use among personnel. There seems to be less recognition of the serious effects that alcohol can have on job performance. In addition, controllers describe their working environment as a place where asking for help, either for a personal problem or for a work-related problem, is extremely difficult.

Since being in ATC is recognized as a stressful occupation, the FAA might consider ways that all personnel could get in routine contact with a counselor or therapist once every 6 months, "whether the controller needs it or not." Routine encounters with a helping professional may begin to reduce the current stigma of seeking out a counselor. At such a session, the counselor could go through a check list of stressful work and non-work life situations. The controller and counselor could review the extent of stress that the controller appears to face and review options for dealing with it. Getting access to help in coping with various types of personal, family, or job-related problems will allow controllers to work more effectively.

5.1.3 The Impact of Outstanding Controllers.

Controllers associate use of memory aids with air traffic controllers considered "weak " or "over the hill." To break this association, experimental projects and research involving introduction of memory aids should seek out the best controllers and elicit their views on design and use of memory aids. All controllers interviewed could relate characteristics of the outstanding or effective controllers they work with; if these admired controllers adopt new techniques for handling traffic or make changes in their normal working routines, other controllers may be more likely to follow their example.

5.2 TECHNIQUES TO MANAGE MEMORY DEMANDS IN ATCS WORK.

The interviews with controllers indicate that the primary techniques controllers learn to use in their work are scanning and intense concentration. For most ATCSs, when traffic or job pressures increase, their response is to become more vigilant, more focused, and more intense in their scanning and concentration. There is a pressing need to study alternative approaches to traffic control, based on an understanding of the memory components of ATCS work. In addition to the role that memory aids can play in managing memory, even greater contributions to ATC may come through introducing techniques to manage memory into the skills of ATCSs.

Techniques that some controllers already use to organize their work are: standardization, visualization, and initially "completing the transaction." Although it is possible for an individual controller to adopt aspects of these techniques, using a memory management strategy such as standardization is easier when all site personnel follow the same routines for ascent, descent, etc. In addition, in a work environment that requires standardization, all controllers will have to try techniques which may initially seem more difficult (or less satisfying) than those he or she has been using. It may take weeks or months for a controller to feel comfortable with the changed techniques or to become convinced that these alternative ways of working traffic are equally

good or better than those the controller has been using. However, on his or her own, there may be limited incentive to learn an innovative approach, especially if the new approach is associated with "weak" or less competent controllers.

Just as standardization is difficult to implement on an individual basis, there are many aspects of managing facility work environments that require site uniformity for best results. Although controllers like to view themselves as autonomous individuals, most employees underestimate the effects of their work climate on their attitudes and behavior. Prohibitions against unnecessary conversation, sanctions against excessive use of alcohol, and provisions for adequate briefings at shift overlap are work situations that all personnel must respect. It is especially important that supervisors institute, demonstrate, promote, train, and enforce these work conditions.

The controllers interviewed admire their colleagues who can prioritize, preplan, and anticipate the work flow. Not enough information exists about how controllers, in actual practice, prioritize, preplan, and anticipate. Successful ways of training these techniques to developmental are also needed. Again, the facility environment must encourage these strategies, both officially and unofficially, training developmental effectively, making time for shift handoffs, staggering starting times, maintaining minimal distractions in working areas, etc. Again, research is needed to understand the management climates and work environments that develop and reward the skillful controller.

An emphasis of team work is implicitly involved in some of the previous discussion of effective environments for minimizing stress and changing work techniques of controllers. Controllers learn a model of self-sufficiency and get limited training in team work. They tend to learn the limits of self-sufficiency through making mistakes on the job; even then, rather than change their approach, they intensify their application of what they have previously learned.

Training techniques are available that would allow controllers to learn their personal and situational limits under various simulated work conditions. Controllers could learn the advantages of adopting a technique or using a memory aid in a training situation. Controllers do not generally learn much about techniques of working cooperatively or asking for help. More research on the organizational conditions that promote or deter team work on the job is needed.

5.3 CONTROLLERS' VIEWS ON TRAINING.

Automation will demand increased skill in formulating and entering information into the computer. Controllers will need to develop skills such as looking at the presentation and typing instructions simultaneously. If automation involves increased use of letters or words, this area requires some investigation; while controllers appear to be able to remember a vast quantity of numbers, they report having trouble remembering simple things such as a person's name. Layout of the keyboard, definition of functions, computer entry procedures, monitors, and information displays will necessitate a common approach throughout the system.

Training for new procedures, whether automation or new concepts such as standardization, require a two-fold training process. Controllers must learn why they need to replace their old ideas and methods with newer concepts or approaches. Then, the controllers must learn the new methods associated with performing the new tasks.

Courses on using the computer keyboard should stress some basic factors, including:

a. Memorization of the keyboard layout to facilitate use of the system, e.g., to make easy and effort-free entries

b. Learning speed and accuracy

c. The intent or rationale behind the process

d. Hand/eye coordination techniques.

The approach to teaching new information, e.g., how to use visualization techniques, should include the most up-to-date methods of instruction, which controllers say they want, such as:

a. Videos

b. Computer based instruction (CBI)

c. Show and tell sessions

d. Informative classroom lecture and discussion

e. Hands-on training with skilled instructors

f. Pacing and segmentation of topics into manageable sections.

The effective use of memory aids or memory joggers and the use of back-up systems need to be incorporated into training programs for developmental as well as FPL controllers. The use of memory aids needs to be systematized as part of the day-to-day work environment or otherwise some or all controllers will not learn to use them effectively. Controllers need to learn their memory limitations and the advantages of back-up systems to reduce reliance on displayed data block information.

5.4 NETWORKING.

Most facilities operate as independent units responsible to their regions; similarly, each region operates independently from other regions. Duplication of effort among FAA facilities is widespread because there is limited exchange of information between staff of the facilities or from each facility to a central information-collection agency. As a result, instructors at one

facility may develop their own training material, unaware that another side has already prepared an excellent manual or video which they could use.

There appears to be rich potential for networking among the facilities to share the volume of information that exist in each region, specifically ARTCCs. A pooling of information could create a "what if" data bank that would exceed all currently mandated training requirements.

Additional information uncovered in the work indicates the need for a video tape library and a range of instructional methods to provide examples of visualization as a tool for organizing and managing the work of controlling aircraft. Controllers express a desire for more use of graphic and less written explanations, better demonstration of equipment and activities within classroom sessions. They want more simulation, both manual and radar, on actual equipment as well as experience in related communications. They call for more realistic traffic scenarios, an updated or new video of "Learning and Remembering," a video tape that describes what happens to a controller after he or she has been involved in an incident in which an accident occurs, and a course designed to teach memory limitations so that newer controllers will get an earlier introduction about the limits of individual memory and the ways in memory aids can increase memory capacity.

A data collection agency or clearing house for information could promote sharing of useful material among FAA facilities. This agency could be part of the FAA Technical Center or the FAA Academy. Its purpose would be to collect, catalog, and make available information useful to controllers, for example, information related to training such as computer based instruction (CBI), relevant ATC videos, and national and local software patches.

This clearing house could also provide other information, e.g., about Controller Awareness and Resource Training (CART) and orientation videos prepared for various facilities. It could also promote exchange among facilities through a newsletter, seminars, and conferences. Controllers reported that they benefitted from human factors training, such as CART. This approach to the ATC situation emphasizes team work, learning one's job-related limitations, and communication among all personnel (particularly pilots and other controllers) working at the common goal of assuring air traffic safety.

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APPENDIX A

MEMORY AIDS: IN USE AND/OR RECOMMENDED FOR TESTING

A1. LIST OF ALL MEMORY AIDS: FROM THE FINDINGS OF THE MANAGERS' AND ATCSs SURVEY.

A1.1 AIDS CURRENTLY IN USE AT FIELD FACILITIES.

A1.1.1 Manual Aids.

a. Cocking strips as a reminder of further action necessary.
b. Red and black printed strips to denote direction of flight.
c. Strip marking as a memory back-up or record keeping device.
d. Highlighted markings to indicate further action necessary.
e. "Red" warning markings to imply immediate action necessary.
f. Strip bay management to correlate aircraft movement.
g. Note pad management to correlate aircraft movement.
h. Status boards for storing essential information.
i. Color coded warning strips/plexiglass to indicate closed runway or runway crossing.
j. Blank strip or strip inverted as caution reminder.
k. Strip shutes from tower to radar (tower); minimizes verbal coordination and strip duplication.

A.1.1.2 Automated Aids.

a. "J" ring/ball (center) to indicate 6 mile separation exists between flights.
b. Off-set leader lines as a direction indicator.
c. Slant/zero (/0) (center) to indicate communications transfer.
d. Vector lines (center) for flights projected route, spacing tool.
e. Alpha-numeric scratchpad entries to provide additional essential information.
f. Time-share software for additional information.
g. Past histories (center) to indicate past flight performance.
h. Interim altitude assignment or other "flagging" indicators to denote that other action is necessary or to avoid this area.
i. Off-set data blocks as a direction indicator.
j. CRD display (center) for assorted stored information.
k. Systems ATLANTA, IDS, etc., for assorted stored information.
l. BRITE radar (tower) for visual scanning back-up.
m. Limited data blocks for advance flight information.
n. Route lines (center) as projected flight indicator.
o. Range bearing indicator as vector aid reference headings.
p. Automatic arrival drop list (tower) for sequence of last 3-6 arrivals (ground control aid).
q. Extended leader lines to denote destination or for unusual flights requiring additional attention.
r. Range marks as spacing tool to assist in sequencing.

s. Runway incursion device (RID) as aural and visual reminder of traffic on the runway.
t. Double intensity of target (center) for bringing attention to the particular flight.

A.1.3 Site Specific Aids.

a. Bright colored flight progress strips for runway closure indicators.
b. Large plastic sign (3" by 7") velcro backed, placed on BRITE radar as reminder of action necessary, runway closures, or restrictions currently in use.
c. Large plastic sign (3" by 7"), brightly colored, as reminder of "vehicle on runway."
d. Red disc placed over wind detector as a reminder that active runway has been released to ground control.
e. Active-inactive sign. Large (6" by 8") sign blue on one side, red on the other to indicate hot or cold.
f. Coast line blink (tower) which indicates when an ARTS arrival track drops off prior to the auto-drop area.
g. Emergency airport/hospital patch (tower).
h. Special use airspace patch.
i. Quick look feature expanded and simplified to allow unlimited observation of all positions (tower).
j. Parachute jumping patch.
k. System saver patch. Patch freezes tracking data on the controllers display in the event of ARTS failure. Remains frozen until the system recovers.
l. Puck board traffic management system. Utilizes a black stripboard with clear strips. Information is written on the strips with a white grease pencil. This system is easy to use and standardizes the way each controller uses the board.
m. Auto-scratch patch (tower); inserts a single-letter exit-fix identifier formed by two digits of assigned alternate.
n. Implied leader patch (tower); allows leader line changes to be entered as implied function using a single character.

A1.1.4 Other Site Specific Training/Educational Material.

a. Scenario which includes similar sounding call signs, incorrect readbacks, and a high traffic volume for complexity (tower).
b. Large (4' by 8') plywood sheet with airport layout. Used for ground control debriefings to simulate traffic movements. Aircraft are scaled to the airport layout and an accurate re-enactment of actual traffic can be simulated.
c. Video tape libraries which include all FAA tapes concerning Air Traffic Control.
d. WELCOME TO OUR FACILITY: a locally devised informational document to assist new FAA Academy graduates in the transition from their home state to their first job assignment.
e. CART: a human factors oriented seminar that deals with system error related topics such as problem-solving, identification of resources, distractions, attitudes, stress anger, judgment, communications, situational awareness, time management, incapacitation and conflict resolution.
f. CBI (Computer Based Instruction) study programs.

A2. AIDS RECOMMENDED FOR USE/TESTING IN PERI YEAR 1 STUDY[1]

a. CAN-Hand-off check-mark system to indicate flight is clear of traffic, at appropriate altitude, and properly navigating prior to initiating hand-off.
b. Time sharing data. This feature has already been expanded except for the use of climbing and descending arrows to indicate aircraft altitude.
c. Systems ATLANTA or other information displaying scope. These information processors, currently in use at some facilities, need more refinement to maximize access to infrequently used information.
d. Non-automated hand-offs to minimize reliance on automated transfer of control. Some facilities have reverted to this procedure.
e. Color-coding of strips and flight stripholders for route direction. Currently in use in ARTCCs but only on flight progress strips which, due to lighting, are extremely hard to read.
f. Enlarged strip holder bays to allow for offsetting (cocking) strips in a more uniform manner.
g. Use of color red to indicate warnings or revisions to route of flight, altitude, or holding pattern.
h. Voice recognition system/playback.
i. Strip shutes between towers and TRACONs.
j. Formatting or mandating how strips are placed in strip bays. Essential for continuity between controllers.
k. Challenge-response checklists similar to air crew lists for position relief briefings and a standardized routine for position relief.
l. Indicator light system (green vs. red) to signify "safe to use" versus "in use." See RID system above.
m. MITRE's ghosting display for spacing assistance to approach controllers.
n. NASA-AMES Traffic Management Advisor for regulating traffic flow between ARTCCs and terminals.
o. NASA-AMES Descent Adaptor: provides descent assistance to center controllers.
p. NASA-AMES Final Approach Spacing tool for approach controllers.

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[1]See Air Traffic Controller Memory Enhancement: Literature Review and Proposed Memory Aids.

FAA Technical Center
Atlantic City, New Jersey

AIR TRAFFIC MANAGER MEMORY ENHANCEMENT QUESTIONNAIRE

This questionnaire was developed to gather information from the population of air traffic managers about possible memory enhancement aids or strategies used in the field that are typically unheard of. Your responses will help other Controllers at other facilities who may not have knowledge of what you already use. Please take a few minutes to respond to the questions below as accurately as you can. Your responses will remain completely anonymous and confidential. You may, however, choose to not answer any items with which you are not comfortable answering. Thank you for your cooperation.

Geographical Region: _____

Facility: _____ Facility Level: _____

Number of Controllers: Developmental: _____ FPL _____ ATA _____

---

1) Are there any aids or strategies that you know of that Controllers in your facility have used to enhance their ability to maintain information in memory?

(If YES, please list and describe them in the space below)
(If NO, please continue with question 2)

a) Type of memory aid or strategy: _____

_____

_____

a) Description of the memory aid or strategy: _____

_____

_____

b) Type of memory aid or strategy: _____

_____

_____

b) Description of the memory aid or strategy: _____

_____

_____

c) Type of memory aid or strategy: _____

_____

_____

c) Description of the memory aid or strategy: _____

_____

_____

2) Are these aids or strategies being used primarily by developmentals or FPLs?

(please check one)

Developmentals _____ FPLs _____

(if you checked developmentals, please continue with question 2a)
(If you checked FPLs, please continue with question 3)

2a) If they are typically used by developmentals, have you observed whether these aids or strategies tend to be discarded as their experience level increases?

Yes _____ No _____

3) Are there any software adaptations (i.e., local patches) that have been made to your facility that you feel further enhance the existing software and specifically enhance Controllers' memory?

Yes _____ No _____

(If yes, please describe in the space below)
(if no, please continue with question 4)

_____

_____

_____

4) Is there any equipment (i.e. hardware) that is used in your facility that you feel may be useful to Controllers' memory (i.e., information gathering devices (SAIDS))?

Yes _____ No _____

(If yes, please list and describe pertinent information in the space below)
(if no, please continue with question 5)

_____

_____

_____

5) In the past 2 years, have any manufacturers tried to influence you into purchasing equipment by demonstrating new software / hardware that might serve as full or partial memory aids?

a) Manufacturer Hardware / Software

_____

_____

_____

_____

6) Does your facility apply any training aids that you feel are unique, enhance developmentals memories and could have nationwide implementation?

Yes _____ No _____

(If yes, please describe)
(If no, please continue with question 7)

_____

_____

_____

7) Does your facility have strip marking or note taking conventions that you feel serve as a cross check or backup system to radar data ?

Yes _____ No _____

(If yes, please describe)
(If no, please continue with question 8)

_____

_____

_____

8) Are there any other memory assists (crutches) in the field you feel enhance controller's memory that we should know about?

Yes _____ No _____

(If yes, please describe)
(If no, please continue with question 9)

_____

_____

_____

9) Do you feel that the interaction between radar and manual Controllers serves to enhance Controllers' memory? That is, does one controller serve as a memory aid to another controller? Could you elaborate?

Yes _____ No _____

_____

_____

_____

10) Approximately what percentage of your total traffic volume is located at satellite airports?

_____

11) How does the satellite airport operation at your facility impact your total operating efficiency?

_____

_____

_____

12) Do satellite Controllers posess enough information (i.e., charts, approach plate, overhead view graphs, etc.) to enable them to control the position without having to refer to additional clip boards or information binders?

Yes _____ No _____

DOT/FAA Technical Center
Controller Memory Enhancement
Field Interview Protocol

General Instructions: The purpose of this interview is to elicit ideas and techniques from the volunteer participant. The goal is to build a body of information on what people are actually using to assist them in managing their limited memory resources. All information will be collected without the interviewees name and the he/she is free to decline to answer any question that causes them concern. Questions will begin from general to specific with the initial efforts of the interviewer oriented on building rapport. The questions which follow are meant as a guide and the interviewer will follow up on any interesting or unique memory management ideas expressed by the interviewee. The interviewer will emphasize that all information is being collected anonymously and that the interviewee's confidentiality will be protected.

Controller Background Information (This information necessary to help organize and sort the response data. It will not be used to identify the individual.)

Your Position: 1)FPL 2)Developmental 3) Staff

Years in ATC_____ Years in the Facility_____

Total Facilities at which you have worked_____

---

1. Lets go back to your training. Try to recall what you were taught that related to managing your memory so that you would not forget important information?

2. How do your recollections of training relate to what you do today in your facility? (Follow up with: Is there anything that should have been covered in training that was not which would have made your entry into actual control easier.

3.What personal techniques do you use that help you maintain the picture? (Probe where these came from. ie self developed or developed by some one else. Here you are looking for tools that go beyond what is formally taught or unique ways of using traditional aides).

4.As your workload increases to the point where you are really busy, which of these techniques do you use and how to you go about managing your workload?

5).When you are working a radar position to what degree do you rely on the display data to keep your memory current? (Probe here for scanning strategy and attempt to identify the relative importance of other sources of information ie strips and other displays).

6). When working radar with strips, what techniques do you use to keep the strips updated.(Follow up with: Have you developed any note taking or marking conventions that are useful to you?).

7). When working a position that does not employ strips have you developed any note taking techniques that are useful to you. (Delete this if it does not apply).

8). Does you facility use any special or unique strip marking procedures in addition to ATP/SOP mandated procedures?

9). How do you keep from forgetting information that you must know but use infrequently?

10).To your knowledge, do controllers who handle large volumes of traffic with ease have any special attributes or techniques?

11).If you could change the system in some way so that the chances of forgetting key pieces of information were reduced, what changes would you like to see happen?

12).Do you know of any memory related job aides in or beyond air traffic control that if purchased or implemented would make your job easier.

13).Is there anything I have not asked you that you believe I should have which would help us understand how people at you facility manage their memory resources.

Close out: Thank the respondent for his/her cooperation. Reemphasize that confidentiality and anonymity will be protected. Ask if there are any questions.

DOT/FAA Technical Center
Controller Memory Enhancement
Field Interview Protocol

General Instructions: The purpose of this interview is to elicit ideas and techniques from the volunteer participant. The goal is to build a body of information on what people are actually using to assist them in managing their limited memory resources. All information will be collected without the interviewees name and the he/she is free to decline to answer any question that causes them concern. Questions will begin from general to specific with the initial efforts of the interviewer oriented on building rapport. The questions which follow are meant as a guide and the interviewer will follow up on any interesting or unique memory management ideas expressed by the interviewee. The interviewer will emphasize that all information is being collected anonymously and that the interviewee's confidentiality will be protected.

Controller Background Information (This information necessary to help organize and sort the response data. It will not be used to identify the individual.)

Your Position: 1)FPL 2)Developmental 3) Staff

Years in ATC_____ Years in the Facility_____

Total Facilities at which you have worked_____

---

1. Lets go back to your training. Try to recall what you were taught that related to managing your memory in each of the following developmental phases of training:
a)FAA Academy b)Facility: classroom as it is associated with book learning c)Facility: radar simulation training d)Facility: OJT as it involves becoming position qualified.

2. How did your past training relate to what you do today in your facility? A) Is there anything that should have been covered in training that was not which would have made your entry into actual control easier? B) Do you have any ideas or do you use any techniques which help you learn new information easier? C)Do you have any methods to help you remember information away from the job?

3.We are interested in memory as you use it. What personal techniques do you use that help you maintain the picture?

4.As your workload increases to the point where you are really busy, which of these techniques do you use and how to you go about managing your workload? Do you find that using these aides is helpful in managing your workload of do you feel that they are added work?

5).When you are working a radar position to what degree do you rely on the alpha numeric display data to keep your memory current?

6)Have you ever had a memory lapse and if so how did it occur? (Note: you may decline to answer if this question makes you uncomfortable.)

7.What do you see as your memory limitations as far as traffic volume is concerned?

8). When working radar with strips, what techniques do you use to keep the strips updated? Have you developed any note taking or marking conventions that are useful to you?

9). Does you facility use any special or unique strip marking procedures in addition to ATP/SOP mandated procedures?

10). How do you keep from forgetting information that you must know but use infrequently?

11)Think about the controllers that you would rate as outstanding. What special skills, attributes or techniques do they have?

12).If you could change the system in some way so that it would be easier to remember essential information, what changes would your make?

13). Is there anything that I should have asked you about managing your memory that I overlooked?

14). Do you have any suggestions for air traffic controllers who want to improve their memories?

Close out: Thank the respondent for his/her cooperation. Reemphasize that confidentiality and anonymity will be protected. Ask if there are any questions.

INTRODUCTORY LETTER:

MANAGERS' SURVEY

Dear

The FAA Technical Center is conducting a multi-year program in Controller Memory Enhancement. This program has grown out of the results of an Administrators Task Force recommendation that memory lapses account for a sizable proportion of controller system errors. The program is sponsored by the Federal Air Surgeon and the Air Traffic Service.

As part of the program we are currently conducting a two phase survey of a sample of operational facilities. We are looking at a cross section across the country based on traffic volume, complexity, uniqueness of operation, and geographical location. The first phase of this effort is directed at facility managers or their designated representatives. Based on our preliminary research it is apparent that there are many local patches, ATC techniques, and memory tools that have been developed at individual facilities which are not known to the rest of the air traffic community. Our objective is to identify and catalog any techniques developed for or by your facility which have an impact on controller memory and might be potentially useful at other facilities or could simply stimulate the creativity of other managers to adapt or develop memory aids for their own facility.

It is recognized that you are busy and that this is just one more survey among many that has come across your desk. Our principle goal is to find ways to help controllers in the here and now rather than waiting for all the automated aids that are anticipated sometime in the future. The information that we collect will be made available to you at the end of the project in approximately 9 months. We would very much appreciate it if you or your designate could take a few minutes and complete the enclosed questionnaire. The point of contact at the Technical Center is: Dr. Earl S Stein, Engineering Research Psychologist, ACD-340. You may call him at any time if you have any questions at FTS 482-6389.

The second phase of this study will involve site visits at a small number of facilities. These visits will involve observation and interviewing of controllers on a non interfering basis. Visits will be coordinated in advance and interview questions

will be submitted to you prior to the visit. Personnel whom we would like to interview during these visits include volunteers from staff, first and second level supervisors, and controllers-FPL and developmentals.

The project is supported by a contractor, Princeton Economic Research Inc. (PERI). They are providing a technical expert as an interviewer, Mr, Stan Gromelski, who is a retired supervisory air traffic controller from Washington DC Tracon. Coordination of visits may be accomplished directly by Mr, Gromelski or by Dr. Stein. Only a small subgroup of facilities responding to the questionnaire will be visited. If you specifically wish to be in that group feel free to contact Dr. Stein.

Thank you very much for your cooperation and patience. We look forward to working with you and hope for successful project which will benefit the controller work force.

Sincerely,

Original Signed By
DR. LLOYD HITCHCOCK

Lloyd Hitchcock Ph. D.
Engineering Research Psychologist

(ACD-340:Hitchcock:ks:5380:12/10/90:Merged File)

Identical letters have been mailed to the attached addresses.

Attn: Facility Manager

On behalf of the Technical Center Controller Memory Enhancement team, I would like to thank you for answering our Managers' questionnaire. We appreciate the fact that you invested the time cooperation of facilities such as yours, we now have the beginning of data base of memory aids, which we hope after further refinement, will turn out to be a catalogue of potential memory saving techniques that are useful to our current controller work force.

The second phase of this research involves field visits to selected facilities that have, through the questionnaire, shown that they have locally developed memory aids/techniques or software patches that have merit for national implementation. The intent of these visits will be to amplify and clarify received responses through the interviewing process. We would like to interview controllers, both FPL and Developmental, first and second line supervisors, and staff personnel, of course, all interviews will be conducted on a non-interfering basis. It is hoped that the interviewing process will bring out additional memory aids or control techniques that controllers use daily to minimize reliance on short term memory.

We would like to schedule a visit to your facility on/or about April 26, 1991. The following, is a tentative agenda to your approval.

10:00am	Arrive at designated facility and meet with facility manager or designated representative along with available staff.
11:00am	Tour facility.
1:00pm	Interview day watch personnel.
4:00pm	End visit, conclude interviewing.

We hope to conduct ten (10) interviews during the time allotted. Each session will be (30) minutes or less. This is where we, once again, need your help. We are looking for knowledgeable individuals who are extraverted. Your assistance in personnel selection would be most helpful and greatly appreciated. If the date selected for our visit doesn't meet with your approval, call FTS (609) 484-6389 and speak to Dr. Stein. The interviewing team will consist of one to three people. Interviewers will be employees of Princeton Economic Research Inc. (PERI), which is under contract to the FAA Technical Center, or will be FAA Technical personnel. All interviews will be confidential. Mr. Stanley Gromelski is the lead person from PERI. He will contact you by phone for final arrangements prior to the arrival of anyone at your facility.

I am enclosing two copies of the interview format. Please provide one copy to your local union, and feel free to contact Dr. Stein at anytime. Thank you very much for your cooperation.

Sincerely,

Lloyd Hitchcock Ph.D.
Engineering Research Psychologist
Controller Memory Enhancement
Program Manager